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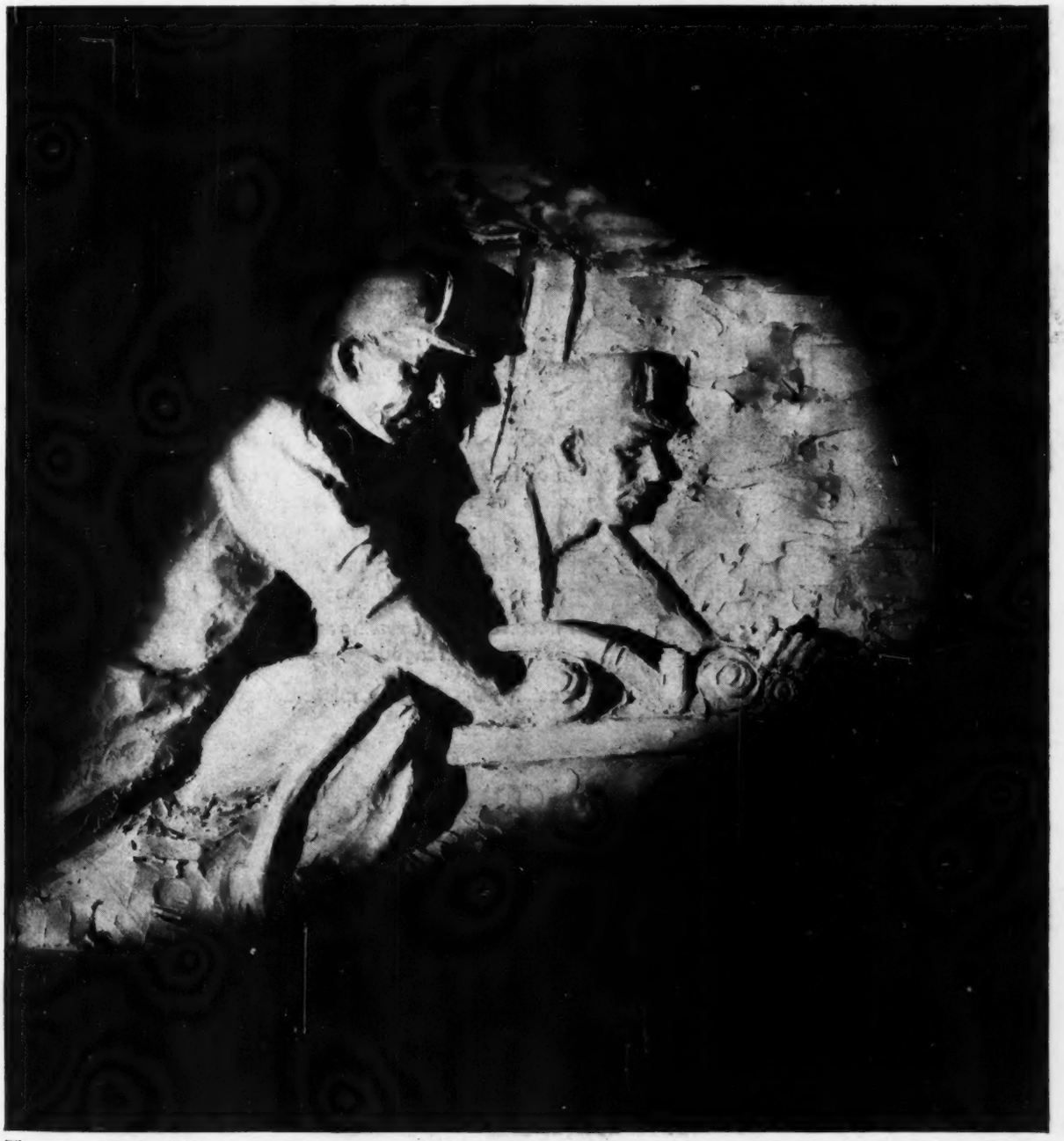
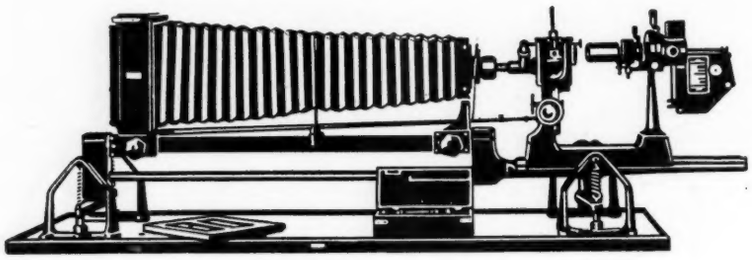


The men with the drill

Courtesy American Blower Company

May 11, 1931



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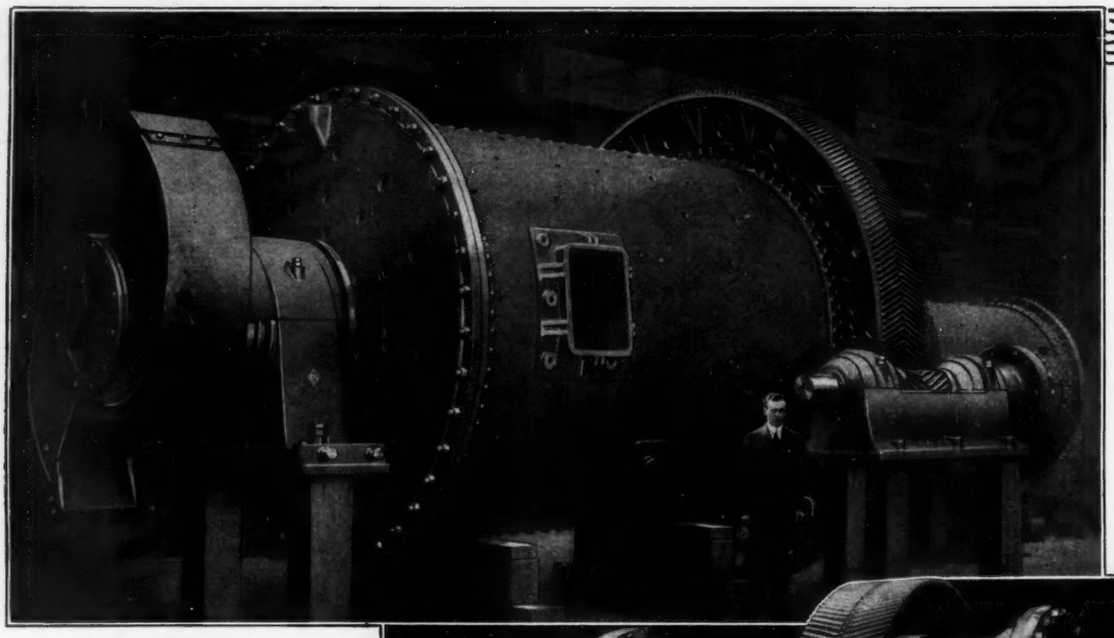
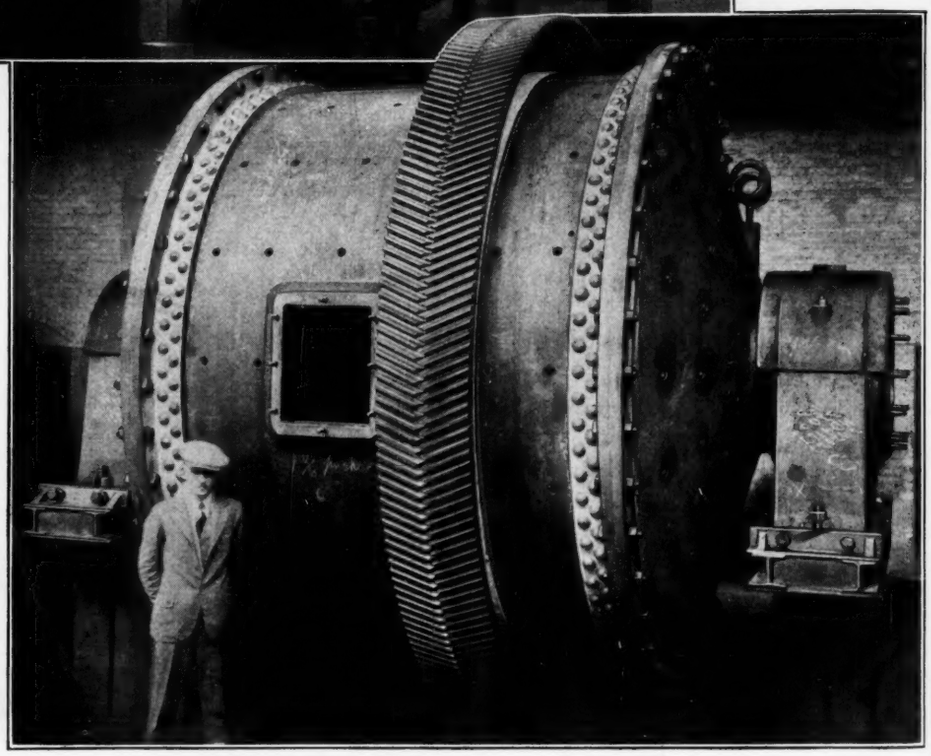


9′ x 12′ Rod Mill for Nevada Consolidated Copper Company.



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Engineering and Mining Journal

May 11, 1931 A. W. ALLEN, *Editor* Vol. 131—No. 9

Technical Writing Is an Engineering Task

FROM Montana comes news that is heartening to those who believe that correct and effective technical writing is deserving of approval and encouragement: President Francis A. Thomson announces a new course in English at the Montana School of Mines. After 1931, graduating students must show proficiency in technical writing, the evidence being secured by examination of all written work presented by candidates seeking a degree. Reports and other written matter will be scrutinized by members of the faculty to whom such material is submitted. It will be judged for organization, diction, effective expression, and the correct use of words. The English Department will act as arbiter and counselor if and when required, in addition to directing the new course. Students whose work indicates an inefficient and ineffective use of words will be required to gain proficiency in technical writing before being permitted to graduate.

The most interesting feature of the announcement is evidence that the faculty as a whole is to co-operate in a task usually considered the prerogative of the English department. Professors of engineering subjects rarely evince interest, or are permitted to evince interest, in the mode of expression of a student. And yet they should make their influence felt in support of organized common sense in its application to the efficient and frugal use of the English language. The effectiveness of a technical article involves a greater appreciation of engineering ideals than of correct grammar; the technical writer should disregard precedent when it ignores frugality, disdains efficiency, and inhibits clarity. The members of the faculty of an engineering school, if the professors are true scientists, must assume responsibility for the training of the undergraduate in correct English.

Every teacher of a technical subject should feel privileged to inculcate and foster a respect for clear and precise expression, which ought not to be considered an attainment unrelated to the acquisition of facts—a divorce that has proved a major reason for the use of slovenly English by university graduates. A single course in English cannot be expected to counteract a lack of discipline and counsel that encourages indulgence in idiosyncrasies and slovenliness throughout the fact-acquiring period of education. Clear, precise, forceful diction, the selection of appropriate words as tools of language, economy of space and of the reader's time—this composite ideal can be reached only by concerted action on the part of every member of the faculty.

The study of English by an engineering student will be made easy if he can realize that effectiveness in result is secured by that practice and revision which lead to an economy of his time only after a period of apprenticeship and experience. The average professor of English, moreover, may learn from the engineer the importance of precision, as well as the part that the frugal use of raw material and the logical design of the sentence structure should play in technical writing. A teacher of English at a university or a school of mines is no more capable of effecting a needed revolution in undergraduate diction without help from the other members of the faculty than the safety engineer for a mining company can achieve a satisfactory accident record without the wholehearted co-operation of every department head in the organization.

Increased State Mine Taxation Undesirable

METAL MINES in one Western state have been subject to two important taxes, one based on a valuation equivalent to three times the net proceeds for the preceding calendar year, the other a property tax based on a value of $5 per acre for all mining claims and on the full value of all machinery and surface improvements thereon or appurtenant thereto. Recently, a Franchise Act added another tax, equal to 3 per cent of the net proceeds, which are, however, subject to an offset of property taxes not in excess of one-third of the amount of the income tax and a depletion allowance equal to one-third of the net income. In addition, a State Fund Equalization Tax was established, providing a levy of $1 for each person of school age in 1931 and thereafter, increasing each year by an additional dollar until 1935, when a maximum of $5 per person of school age will be collected. This tax will operate to increase tax rates. An increased tax on individuals is another product of the legislature, as was also the segregation of tangible and intangible property for taxation purposes.

The increase of taxation recorded in the foregoing is discouraging to mining enterprise. One mine operator is reported to have said that "Capital surely cannot be persuaded to come into this state, gamble on finding ore, gamble on metal prices and markets, gamble on successful treatment processes, gamble on the premature depletion of ore reserves, and then run the added risk of a tax fixed to suit the demands of the legislature."

The multiple system of taxing net earnings is obviously inequitable. The new taxes referred to increase the inequity. Legislators can wisely promote progress and development by maintaining state expenditure within a reasonable income; or they can, as in the case in point,

drive industry away by excessive taxes. The deflation of government must accompany deflation of commodity prices, or enterprise will wither away, and, in the end, local government will have to adjust its expenditures on the basis of a greatly lessened income. Ways and means of increasing the number of tax dollars are being discussed by legislators, but the prime subject should be ways and means of diminishing the number of tax dollars and spending each efficiently.

The Capture of Colloidal Gold

ATTENTION has been drawn at necessary intervals to what has been termed the fiction of colloidal gold. No doubt is cast on the assertion that gold can occur in the colloidal state, or that it does so occur, possibly in raw ores. But an occasional warning is apparently necessary to discourage belief in the contention that ordinary assayers—with high technical competence and intellectual integrity—fail to report gold in certain samples because it occurs therein as a colloid. Rarely can the proponent of an argument of this character be persuaded to accept responsibility for a statement or explanation; but, by happy chance, a photostat of a remarkable report has come into our possession, submitted by a firm of commercial assayers and analysts that has apparently been operating for two decades. The location of the assay office will not be disclosed. Suffice to say that it is situated in a populous center of a mining state. In the interests of science, and to dissipate doubt that might arise if reference were to be made merely to the tenor of the report, it is quoted verbatim, unspoiled by correction, as follows:

"Pardon me if I give a little spiel about Tellurium Colloids, because that is what bothered the smelters for fifteen years, and they mastered it in connection with certain ores, but when they tackled copper, iron, nickel, manganise, cobalt, silver and gold ores they threw up their hands and the hands are up yet.

"In the main ledges and spurs south of Mt. Whitney and over in Colorad Arizona and New Mexico and down into old Mexico sixty five percent the commercial minerals are Colloidal not all but most all except copper; we think we are nearly right because we have taken them apart and found this statement to be about right. For some reason selenium and telurium is joined up with other minerals in a different form from that found with straight quartz gold and silver ores.

"We have found that in the southern samples the telurium has formed a telurium silicate in the form of cement in which the gold has been replaced by nickel, platinum cobalt and manganise. The clear quartz and copper carries most of the gold of the sample. The balance in switched in with the telurium cement and other minerals and carried away by heat which is necessary to liberate it from the silica.

"Years ago when the chemists were trying to help the smelters out with the telurium complex to get the gold and silver away from the telurium one heard nothing but telurium hindering the recovery of silver and gold the miners and laity thought after a while that telurium did not combine with any metal but gold and silver, but now they know teluric acid combines with most any metal except selenium and vanadium.

"So in making an assay unless the teluric acid is roped down and tied it combines with all precious metals and any metal if the metal exists in the colloid form. To 'rope' the acid down requires a vacum furnice and proper heat and time, and this leads into the abode of Einsteins fourth dimension.

"So in treating the sample you sent me with a pressure of thirty two to the sq. inch and a flux for gold and sulphur and one will get the nicest gold bead ever taken out of an oven.

"An analysis of the bead shows it to be composed of a little gold, silver, COPPER and sulphur.

"Hence the following: Gold, $1.20 per ton; Nickel & Cobalt, 51 per cent; Manganise, Trace; Copper, 11 per cent; Iron, 24 per cent; Silica, 14 per cent."

When the small boy was asked to spell a certain word and did so correctly, the teacher evidenced approval by saying "Very good," to which the youngster indignantly replied "Hell! It's perfect." Similarly, this analysis is perfect. Even after disregarding the gold and the trace of "manganise," the remaining metals and the silica account for exactly 100 per cent of the contents!

Such reports may hearten the prospector and enrich the type of establishment that fabricates them; but they are pernicious in their effects on the findings of analysts of repute and experience. Some selective method for the elevation, in the public mind, of those assayers who have earned a position of respect and confidence in the mining industry, meanwhile effecting the repression of quacks, would do much to discourage a type of pseudo-science that is being used to camouflage incompetence.

Accounting as Practiced by Mining Companies

IGNORANCE is frequently a blessing to the possessor thereof. He who desires knowledge may end only in confusion. Or so, at least, an investigator decides after a witching afternoon spent in the company of this season's crop of reports by mining concerns. His motive had been of the best—he desired only to compare the effect of low metal prices on the incomes and assets of some of the outstanding corporations in the field of non-ferrous metals. What is profit? What is loss? What is depreciation? What is an asset? Simple questions these, and ones to which an answer would have been volunteered readily had they been asked before the survey was attempted. But no longer does he presume to know. Peril lurks in every term with even the faintest taint of lucre.

A comparison of the results obtained by Inspiration Consolidated and Miami Copper in 1930, for instance, would seem easy. The companies operate contiguous and similar properties; they have identical problems to face; they have been in operation for about the same length of time. Inspiration, in determining profit for 1930, subtracted the cost of the copper sold from the total sales. Miami, to arrive as the same conclusion, subtracted the

cost of the copper produced from the total sales. In a year such as 1930, with large carry-overs of metal from previous years, this difference makes comparison of results impossible without further calculations by the curious shareholder or layman. Similarly, in the balance sheet, Miami, shows the total value of its plant and equipment, after deduction of all depreciation charges on the assets side—the amount in 1930 having been $4,908,660. Inspiration, on the other hand, shows the capital invested in its plant—$21,509,993—under assets, and lists the depreciation reserve—$8,123,304—under liabilities. One must exercise powers of subtraction before determining that, if Miami's accountants had been turned on the job, Inspiration's fixed assets would have been $13,386,689. Similarly, Inspiration values its copper on hand at cost (9.67c. a pound); Miami discreetly says nothing about the basis on which its copper is valued.

So the comparison might continue. Apparently, the two enterprises have nothing in common. Small wonder that, when a merger between mining companies is proposed, the stockholder never knows whether he is getting the better or the worse of the bargain.

Proper Equipment Maintenance Essential to Efficiency

ADVICE given to New England industry by the active, efficient New England Council for its guidance in these trying times might well be taken by mining companies at large. As to the best course to be pursued today, this body has recently broadcast the recommendations of several hundred executives within its purview. Of these men, 303 recommend that machinery and equipment be overhauled now, when business is quiet, and that thereafter it be kept in condition by an adequate maintenance program that forestalls breakdowns and minimizes repairs.

The importance of maintaining equipment in good running order needs no emphasis. Yet the need is often disregarded, although deterioration of machinery proceeds at an accelerating rate as neglect continues. As much as elsewhere, this negligence at mines and metallurgical plants spells lessened output, while labor and other charges remain unchanged. An example of such maladministration of a company's business is to be found in a milling enterprise not more than a thousand miles from this publication's offices. There both dry and wet methods of concentration are being used. In the dry mill, dust conditions are extremely bad. Bearings are cut out quickly, though repaired infrequently. In the wet plant, equipment is in poor condition, floors are wet and dirty, and "slop-overs" rule the day. The net result of these conditions, aside from the hazard to employees, is that some piece of equipment must often be shut down, with resulting loss of output or lowered grade of product. In consequence, the mining operation, which might be profitable, is conducted at a loss. Seemingly the mill dust has blinded those in charge. These executives could profitably adopt another recommendation of the New England Council, in addition to that mentioned, which urges general house-cleaning. With dirty plant and equipment there can be no proper maintenance. In importance, proper maintenance of equipment often outranks its modernization.

Alaska's Increased Appropriation

THE ARTICLE on Alaska in this issue, by Mr. Dwight L. Sawyer, is particularly timely in view of the announcement by the Department of the Interior that $250,000 would be available on July 1 for an extension of investigations on the resources of the region alongside the Alaska Railroad. This sum, voted by Congress in its recent session, is in addition to the regular appropriation.

The United States Geological Survey, through which the investigations will be chiefly organized, plans to commence work as soon as possible, advancing money from its own funds, in view of the necessarily short season. Deserving of particular commendation is the announcement by the Department that "As fast as given investigations are completed they will be reported and the facts made available in Alaska without reference to Washington. . . . The Geological Survey will maintain throughout the year a representative in Alaska, with headquarters at Anchorage, to work with prospectors and mining companies, and make available to them the material gathered by the surveys herein provided." This decision will meet with enthusiastic approval. The outcome will greatly enhance the value of the work.

The occasional slowness of government publication machinery—excepting, of course, in the issuance of the *Congressional Record*—has caused unjust criticism of the Bureau of Mines and the Geological Survey. The innovation proposed in connection with the Alaskan investigation will doubtless prove worthy of extension as a general policy when circumstances permit. Reports from the Bureau and the Survey are usually awaited with keen interest. As apt now as when it was uttered twenty centuries ago is the contention that "He confers a twofold benefit . . . who gives it quickly."

Producing and Manufacturing

NATIONAL and international trade and commerce, in the last analysis, is a series of barter transactions. This point was stressed recently by the chairman of the Westminster Bank, who added that "Between the raw material and the finished product are numerous preparatory and finishing processes, at each stage of which production costs of all kinds have to be added. . . . When a violent fall occurs . . . in the value of the raw material, because these intermediate costs cannot be reduced simultaneously, their weight becomes disproportionate, and the price of the finished product is thrown completely out of harmony with that of its basic constituent. The primary producer is thus unable to take in exchange for his commodity as large a quantity of manufactured goods as that to which he has been accustomed—to the detriment of himself and of the manufacturer alike."

The obvious remedy is to reduce costs, "to explore every avenue of economy and to put into immediate operation every means this search may reveal . . ."; and the recent history of the metal industry has shown that the objective is easiest secured by a merger of producing and manufacturing interests. Silver, which shows the greatest disparity between market price and cost to the ultimate consumer of manufactured goods, has yet to benefit from such a union.

WHAT OF ALASKA?

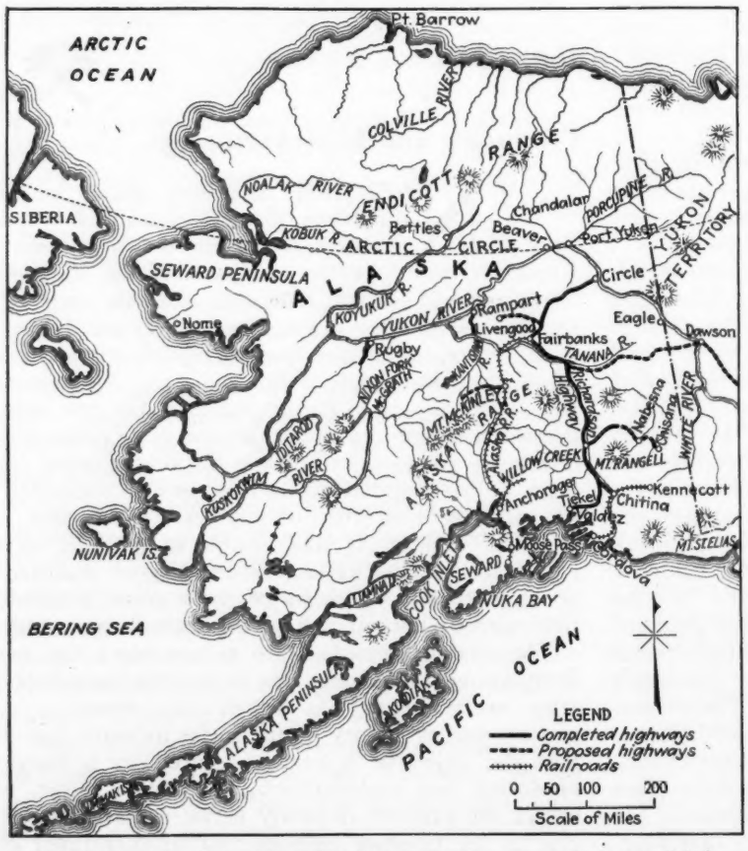
FORMER OBSTACLES to the development of the Territory's mining industry are rapidly disappearing. Transport facilities — trail, highway, and railroad — have expanded markedly, and, together with increasing use of the airplane, are effecting exploration of many new and promising districts.

Dwight L. Sawyer

ALASKA has been referred to as America's last frontier, and rightly so, for it has an area of about 600,000 square miles, and a population of only 60,000, about half of whom are Indians. Comparing it with a country whose climatical conditions are similar, Sweden has a white population per square mile 600 times that of Alaska.

Only about two-fifths of the entire Territory has been surveyed on a scale up to exploratory standards; and there still remain more than 200,000 square miles that have not been mapped.

The significance of the handicaps which retard the development of isolated and inaccessible areas can be appreciated fully only by those who have experienced them. The swamps, brush, and rivers, many of which are deep and swift, make summer travel in Alaska inadvisable. The ideal time for prospectors to take their outfits into the areas they wish to work during the summer is in the spring just before the break-up. Then the rivers and swamps are frozen over and the brush is covered with snow. This applies whether dogs or airplanes are used for transportation, as landing fields are not always available and planes equipped with skis can land almost anywhere on the snow.



Sketch map showing mining districts of Alaska and various completed and proposed transport routes

Several factors are helping to remove the handicaps which have hampered the development of the Territory's mining industry. Some of these are: a better understanding of the really favorable conditions prevailing there; constant improvement of transportation facilities; the experience gained in previous mining ventures; and the success of present mining enterprises.

Alaska, with the help of federal funds, is spending millions of dollars on highway and trail construction, which is constantly opening up and furnishing better transportation facilities to mining districts hitherto undeveloped. The proposed international highway connecting Seattle, Wash., and Fairbanks, will, when completed, make more accessible some of the unexplored mineral areas in the interior of Alaska.

The airplane is competing with and to a large extent replacing dog teams for reaching regions not served by other means of transportation. An illustration: For the last two years three prospectors have been prospecting in an area out from Fairbanks. Their first trip in was by dog sleds, and it took them almost three weeks. When they arrived at their destination, they killed their dogs so as not to have to feed them valuable food. At the close of the season they walked back to Fairbanks. This last spring three planes of Alaska Air Ways, Inc., left Fairbanks with these prospectors and their outfit, and in three hours' flying time had landed them at their destination. Before leaving, the pilots had made arrangements to return for the prospectors in the fall. The people of Alaska are really air-minded, and more flying is done there per capita than in any of the States.

The government railroad which runs between Seward and Fairbanks is actively engaged in promoting the development of mineral resources tributary to it for the purpose of increasing its freight tonnage. Through the co-operation of the U. S. Geological Survey, an intensive study is being made of the areas along the railroad that are most favorable for the early production of mining tonnages.

All of the $250,000 that will probably be appropriated by Congress "for the continuation of the investigation of the mineral resources that will affect railroad tonnage" will be spent by the railroad with the assistance and guidance of the U. S. Geological Survey. Just how this money will be spent is problematical, but part of it will probably be used

U. S. Geological Survey party in the Kantishna district, with geologist Fred H. Moffit in charge

to finance concentrated geological work in districts of known mineralization. Also, funds will probably be available for sampling and preparing reports on mining properties, similar to those made by the Department of Mines of Canada. This activity has for its object the interesting of capital in the development of the mineral resources, and such reports are invaluable to engineers investigating the economic possibilities of a property or a district. A consensus of opinion of good authority indicates that lode mining operations contiguous to the Alaska Railroad will be in the next five or ten years as much as ten times as great as they are at present.

The total value of the mineral output of Alaska in 1930 was $13,602,000. Of this amount, according to the U. S. Department of the Interior, gold accounted for $8,394,000, which is an increase of more than $633,000 over that produced in 1929. Preliminary figures published by the director of the mint indicate that the gold production of the United States for 1930 exceeds that of 1929 by only $500,400. This means that Alaska's increased gold production of $633,000 in 1930 has more than offset the decline of $132,600 in the gold production of the States. This increased production of gold in 1930, in spite of the serious depression in so many of the nation's industries, is an encouraging feature that gives assurance of still greater increases in gold production as general conditions improve and more capital becomes available for exploration and development.

During the last few years the Territorial legislature has had limited funds available for paying transportation expenses of prospectors and their outfits. Each prospector may receive financial aid not to exceed $150, and in return must submit a report on his season's work. According to the annual report of the Governor of Alaska for the fiscal year ended June 30, 1930: "During 1929-30, 298 prospectors received such assistance and 171 submitted reports. Many of the data contained in these reports concern regions about which nothing has been published and very little is known. Several prospectors reported finding promising mineral deposits, but, as yet, development work has not progressed to the point where their actual extent and value can be determined."

The Alaska Range, with its slopes and foothills in the south central part of the Territory, is a large area which warrants thorough prospecting. The range consists primarily of a large granitic mass which has been intruded into sediments and older igneous rocks. Most of the prospecting in this area has been for the more easily worked gold placers, and practically no prospecting has been done for metalliferous lodes, although the geological conditions for their occurrence are favorable.

One of the mining regions in which development has been held up by poor transportation facilities is the Kantishna district. It lies west of the Alaska Railroad, north of Mount McKinley, and includes the area drained by the Kantishna River and its tributaries. Until a year ago, the only means of reaching the district, other than by airplane, was by a boat trip of several hundred miles down the Tanana River and up the Kantishna River, or by a 120-mile trail which crosses numerous unbridged glacier streams. The McKinley Park highway, now under construction, extends about 75 miles westward from the railroad, and present plans call for its extension into this district. This highway will furnish an easy access into the area and will stimulate its exploration and development. The region has undeveloped deposits of gold, silver, lead, zinc, copper, and antimony, some of which will some day be mined at a profit.

Airplane transport of supplies into the Chandalar district

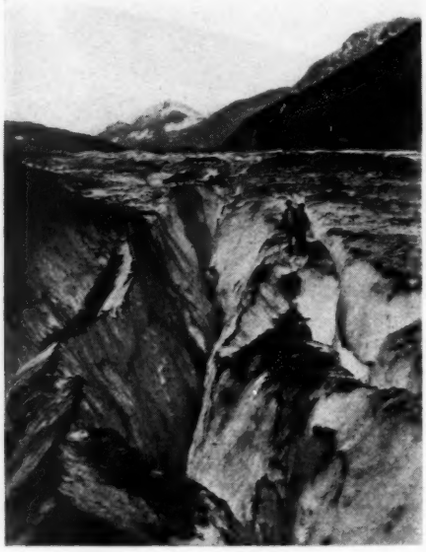
Any description of the Kantishna district is incomplete if it fails to include the two well-known pioneers, Joe and Fannie Quigley, who have prospected and worked their properties there under adverse conditions for the last fifteen years. They have mined some lead-silver ore, but they do not attempt to ship any with a value less than $200 per ton.

The Chandalar district, lying 120 miles north of the Arctic Circle at about 67 deg. 30 min. North latitude, is another area which, owing to its inaccessibility, has received little attention from prospectors. This district has produced some placer gold, most of which is coarse and rough. The lodes found to date are small, high-grade gold-quartz veins that occur in fault fissures cutting the schist country rock. The Little Squaw mine, of the Chandalar Mining Company, is the best-known property in the district and, for a short time, operated a small three-stamp mill. This is undoubtedly the farthest-north gold mine and mill in the world.

Ramsay Rutherford gold mine above Valdez glacier, at an elevation of 6,000 ft., in the Valdez district

Prospector's cabin at Mount Eielson, in the Kantishna district

The area north of the Wrangell Mountains and drained by the Nabesna, Chisana, and White rivers is widely mineralized. Considerable coarse and rough gold, copper-silver nuggets, and nuggets of copper weighing from a few ounces to several thousand pounds have been found in many of the streams of this region. Although this entire area



Crossing the Valdez glacier on the trail to the Ramsay Rutherford mine

is geologically favorable for mineral deposits, little lode prospecting has been done in it, owing to its inaccessibility. Recent developments of the Nabesna Gold Mining Company, on the Nabesna River, where a likely looking gold vein has been found and the company plans to build a mill, have stimulated interest in the district. A highway, which is being built into the area, leaves the Fairbanks-Valdez, or Richardson highway, at Gulkana, and is to be continued beyond the Nabesna district into the Chisana area. From there it will probably be extended to the White River and the international boundary.

In the Fairbanks district the successful operation of the Fairbanks Exploration Company has fully demonstrated the feasibility of cold-water thawing and the removal of large thicknesses of frozen muck preparatory to dredging. These operations will probably stimulate the working of other placer deposits where the margin of profit is small and the problems of muck removal and thawing have been indeterminable factors.

Interest in lode mining in the Fairbanks district has been renewed, and, in 1930, the gold production from its lode mines was 50 per cent larger than in 1929. The properties responsible for most of this production were the Mohawk and Ready Bullion mines, in the vicinity of Ester Dome; the Crites-Feldman and the McCarty mines, on Fairbanks Creek; and the Rhoads-Hall mine, on Bedrock Creek. These mines are operating on relatively small high-grade quartz veins carrying free-milling gold mineralization. The ores are reduced in a variety of mills, which use stamps, Chilean mills, or ball mills for crushing, and recover the gold by straight amalgamation or amalgamation followed by table concentration. In the district are other larger and lower-grade quartz veins and sheeted areas which have possibilities for low-grade operations, but not enough development work has been done on any of them to prove up profitable ore tonnages.

In the Valdez and Tiekel districts are many gold-quartz veins which have been worked in a small way by individuals with limited funds. Some of these properties are in inaccessible places, and, to reach them, one or more glaciers must be crossed. The difficulty experienced in crossing glaciers is not as great, however, as one might think, for their central portions are generally solid and easily traveled; only their marginal and terminal portions are fractured. Other areas where gold lodes occur and where gold lode mining activities are on the increase are the Willow Creek, Moore Pass, Girdwood, Nixon Fork, and Nuka Bay districts.

Alaska offers to the prospector vast unexplored mineral areas, and to mining companies opportunities of acquiring promising prospects. In spite of the intensive highway construction and the probable influx of many prospectors, these immense areas will still be partly unexplored for many years. Moreover, the superficial mineralization of many areas in Alaska is as great as that of some of the highly productive mining districts in the various States; also, geological conditions in these areas are just as favorable as those in the aforesaid mining districts. One who has seen these districts in the States, punched full of holes, and who has traveled over these areas in Alaska which are barely scratched, cannot help but see that the mineral resources of Alaska are undeveloped and that they offer great possibilities.

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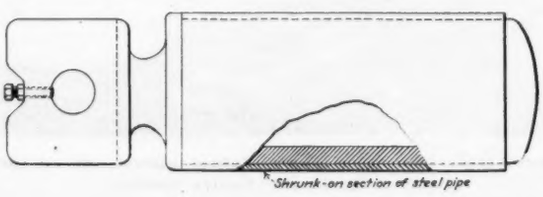
Pump Plunger Repair

WORN pump plungers, causing leaking stuffing boxes and increased consumption of packing material, influence adversely the efficiency and maintenance costs of a reciprocating pump. When confronted with such a problem and no spares are available, slightly worn plungers can be repaired by rectifying the uneven plunger surface in the lathe and providing press-fitted bushings, with the new plunger diameter, for the stuffing-box flanges and rings. This, however, will decrease somewhat the capacity of the pump, because of the smaller diameter of the plunger. In a more efficient and economical procedure adopted at the concentrator machine shop of the Moctezuma Copper Company, Nacozari, Sonora, Mexico, the worn pump plunger is restored to its original diameter by a carefully shrunk-on and turned steel pipe section, or bushing, as shown in the accompanying sketch. The bushing can be removed when worn and replaced whenever necessary.



Clastic Form in Size Measurement

Ernest A. Hersam

THE recognition of size and shape, attributable to the fragments of clastic material, is made difficult and inexact by the indeterminate variables inherent in the undertaking. Our engineering practice lies unimproved or undeveloped in many cases from this cause. It appears possible that by directing more thought to the details of this problem there may emerge a more common desire for uniformity in our customs of measuring, classifying and designating the qualities of crushed ore, rock and other materials for many operations such as we first recognize in sizing and grading.

Whenever we undertake to apply principles with precision to size-classification, representing so the magnitude of pieces, we are confronted with the fact that we have no adequate standard by which to designate size. There should be units, always, to make observation articulate with theory. Units are the connecting links between principles and practice; and they embody the provision necessary in scientific work. They are needed accordingly in mineral beneficiation as they are in all other scientific interests. It is true that we have accurate screens. These by exactness and dependability have become highly creditable to the manufacurers who furnish them, but the expression of size, shown by screens, is subject to such limitations as are found in all other ways of measuring clastic material. The mixed products from screens require a qualifying appraisal that cannot readily by represented by a simple numerical value based upon any simple unit. Size, expressed with qualifications, becomes involved. Averages are resorted to with acknowledged indefiniteness, for in these the complications of shape and the manner of performing the mechanical separation are wordy descriptions needed for the illustration of the size. All this, which is inconvenient, is made serious by compelling the use of size-values that are not transferable from one type of operation to another; sometimes from a test-process to economic operation.

Shape, the important modifying feature of size, has much to do with the indefiniteness of sizing practice. The measurement of shape is unapprcachable by common procedure or by simple definition, which is owing to the fact that we have no basis for the measurement and recognition of shape in many of its aspects. Without regard for shape size can scarcely be shown to exist, and certainly not in terms other than the most general. On account of the disturbing influence of this unmeasurable factor, averages, which are then deprived of the basis of reality, and which are used in our calculations attempting the highest accuracy, become indefinite, because the elements upon which they are based remain indefinite and unknown.

Suppose a person to be given a piece of crushed stone and asked to state his opinion of its size. We discover that we are on ground where there are defensible differences of opinion. Without hesitancy the questionist could affirm that the fragment weighed about half a pound. Being reminded that size, not weight, is the question, he explains that the specimen approximates the size of a billiard ball. Being told that a billiard ball is not a unit of size, he explains that the fragment occupies space approximating eight cubic inches. Being reminded that size is not volume, and after discussion, being unable to put the flat specimen in a pocket that would receive the billiard ball, it is explained that the fragment is about five inches long, three wide, and half an inch thick, but that it is very irregular and probably is larger than a billiard ball in some respects, but smaller in others.

In practice, convenience in handling figures in the category of size. So also do resistance to movement, conspicuousness, and many other qualities. These all have some bearing upon a purpose, and are evoked by some preconceived idea of what size is going to do. In the end we find that our idea of size approaches an association with utility, and is dominated by a clear purpose when in view. Conspicuousness as the object lies flat upon its side aids in finding it. We have the right to adopt such a meaning of size if we desire. Total surface also has something to do with size. In certain applications the surface is the expected and the accepted exponent of the size; it determines the rate of reaction, it indicates the work that was done in crushing it. Perhaps, again, the fragment is hollow, like a cup. Size is, then, its capacity to hold something. Gold particles, or "colors" in alluvials, are sometimes like this.

No single purpose warrants a universal value of size. If volume concerns us, while we may allow volume to signify for us the size, there is yet an indecision in regard to the voids, alveoli, or pores it may contain. Ultimately, if not directly, the size becomes influenced in some measure by the specific gravity. Similarly, the question of the condition of the surface, as well as the extent, arises, introducing relationships of moisture, adsorption, and adhesion, modifying the frictional coefficient and the behavior in massed aggregates, and likewise the degree of compacting and the space occupancy under known conditions. Length, breadth, and thickness of the fragments may be taken to be significant dimensions for many objects, but these dimensions vary widely and irregularly in clastic materials. Such dimensions may be axes: they are influenced in magnitude by the selected orientation. Lines through some conceived center such as the space center or the center of gravity cannot be found, while over-all dimensions are subject to off-sets, channels, and irregularities that defy description. In reality, size eludes the precision that we often ascribe to it, and in the end we are led to disclaim accuracy and to define it only by the association of size with a purpose.

Purpose, accordingly, must be accepted as a condition influencing size. With purpose known, and shape-tendencies recognized, the correlation of the material thing with the ideal can be approached in some measure of definiteness, but the surface of the fragment may be the feature of interest, or the volume, the diameter, or the compactness, the symmetry, or a combination of these. The correlation of all these judgments of size to suit interchanging purposes requires a knowledge of the material and of the purposes and a study of factorial values. In the trades, and the manufacture of commodities, standards of shape have taken origin, furnishing substitutes for complete measurement. Size, there, becomes restricted to the purpose, and harbors the implication of unexpected aspects. We find there the size of hats, of nails, of shoes and of warships. In rock crushing, however, the products allow but little precision, yet the material reveals tendencies that, between limits, may be defined and represented. Shape and size alike pervade all our resources in the treatment and handling incidental to mineral beneficiation.

We find these qualities, size and shape, dominant in determining the capacity of chutes, the behavior on grizzlies, and the action in crushing machinery. They are factors in designing launders and sluices, modifying the required gradient and the form. They modify the rate of settling in water or other media. They are the key to required pulp densities, which dominate the operations of decantation, filtration, concentration, flotation, or fine grinding. They modify the angle of repose, either in the dry state or the wet, when lodged or when compacted, and they modify the effective forces in sliding on inclined surfaces, or through

orifices. They exert an influence upon the proportion of interstitial space in massed material at rest, during movement, or after compacting, and underlie the capacity of settled pulp for inclusive sediment or interstitial slime. They govern the rate of percolation, the retention of water or solutions, and the required extent of superficial penetration in extraction processes. They underlie requirements in agitation, and modify the rates and conditions of displacement, decantation and of washing. They qualify all processes of table concentration, jigging, hydraulic classification, free and hindered, as well as of every incidental condition of embankment and obstruction. They are the controlling influence in air separation and are a consideration in hand sorting. We find these qualities of the greatest influence in all processes of milling and mineral beneficiation. We wonder how far we can expect improvement to go in close sizing, and what is to be found at the limit of our resource.

Although screening confuses all varieties of shape, ignores friction, porosity and many qualities, it doubtless is the necessary procedure by which size, applied to masses of clastic material, will have to be judged for a long time to come. Symmetrical bodies, such as cubes, spheres, or octahedra, could be ranged in any one of numerous ways to measure them, but broken material can be graded only roughly, and by making an arbitrary preliminary judgment of what size means, and by striking averages wherever we can learn upon what averages may be based. Small particles cannot be handled, counted, nor given separate consideration: they require a process of averaging. Screening furnishes the best composite judgment of this, but the measurement by screens must be interpreted, always, with awareness of the purpose and of the character of the material along with that of the mechanical operation of the screens in the broadest sense.

Screen measurement of grains is necessarily indirect. The sizing is an involved and circuitous process. To represent a single size there must be used two sieves, a coarser one, which barely allows the material to pass, and a finer one that barely resists it. The real average may be nearer the coarser screen or the finer one. The probable average is indicated by the condition that lies beyond, in the proportion of still finer and of still coarser material. The elementary act of sizing, however, is complete, without extrapolation, when shown by the two limiting screens. Extra dimensional indication is only a further evidence of the indefiniteness of precise screen measurement and a warning of the need of closely graded standards and of the definition of a size. Wherever a fixed size-value is required for calculation or for the more refined purposes, some imaginary mean must necessarily be assumed.

When size is measured by screening, since its aspect is known only in terms of the dimensions of screen apertures, all idea of size must be restricted to products of screening, pending the acquirement of any modifying data that other size judgments would require. Screen size is, then, best represented by the symmetrical solid form of the particle that can pass, idealized in symmetrical dimensions to the restricting dimension of the screen opening. Such a solid form has surface and volume: and with its shape conventionalized, it becomes a basis for the computation of all linear, surface, or special qualities. Such size, or such average size, of particles is the embodied, idealized screen size which is the basis upon which all qualifications of size will rest for any purpose. To represent and clarify the idea of size it is necessary first to idealize the shape to a symmetrical form, and to show the ideal of size by a diameter or a dimension of linear value. Whatever is known, or whatever may be a purpose in use, should be treated as a characterizing and specific factor modifying this ideal size. To signify surface, the square of the dimension multiplied by the shape factor, such as would be the numeral six in the case of cubes, or of *pi* in the case of spheres, should be used to indicate the value corresponding to the dimension of the screen-mesh size. The solid content deals correspondingly with the cube of the dimension. A single dimension, with a coefficient based upon the qualities known, we should regard as the expression of the definite theoretical size of average particles specific to any purpose correlated in whatever characteristic may be known. Surface, in such cases, is the quality of visibility, or exposure. Volume is the necessary basis which with density constitutes the mass. Diameter is the simplest expression of size if symmetry can be assumed, and is the quality by which we usually designate size knowing it to be applicable to spheres, and by extension, imperfectly, to angular forms.

Our judgment, in terms of diameter, by measurement on screens, is thus verified only by measuring the screen apertures, and to judge the size of pieces that are related to the screens it becomes necessary to recognize shape of the fragments. Nothing is known about the size of a piece until this may be afterward learned, except that which is inferred from the dimensions of the apertures of the two limiting screens. Diameter, learned by screening, accordingly must be the dimension derived from the averaged mesh of the two screens. This is commonly and best based upon a logarithmic mean, and the shape of the particles must then be idealized, so that dimension may have meaning or be made convertible to varied purposes.

The cube is chosen, usually, to exemplify solid form by linear dimensions. The practice is so firmly fixed it would be radical to depart from it in the uses that it now serves. For the utmost freedom for the characterization of form, however, the sphere is the starting point of shape, the zero value of form, and it should be preferred. Dimension or diameter then signify all there is characteristic of linear, solid, or superficial size. If screen dimensions are the basis of the measurement, a known factor correlates the screen with the spherical diameter. Elongated apertures and grids present the smaller dimension as the limiting or effective one. For elliptical openings, the smaller axis, as for round openings the diameter, becomes the shortest dimension which is mainly expressive of screen size. Factors are required to show the degree of average *elongation* of the fragments, and of the average *constriction*, based upon the ratio of the major and of the minor dimension to the diameter of the spherical volume. Factors are required, also, to show the relations of differences in procedure. These include, the duration, the character of impact, the quantity upon the screen, the proportions present, the abrasion and the friction, and they must be known in the terms of factors of relationship. The factors of hydraulic and air classification, of compacted density, and of angles of repose, all then will take form. The practice of the future will require simple terms to express size; and the simplest will be the diameter of the sphere, modified by the factor or the factors befitting the material and the purpose.

The adoption of the added refinement in the manner of these departures requires no alteration of our present customs, or habits of thought, so far as they go. It necessitates only the call into service of the supplementary possibilities that stand in readiness. The practice involves:

1. The adoption of a dimensional expression of size, attributable alike to linear size, to surface, or to volume, in terms of the diameter of the sphere.

2. The adoption of basic factors of relation between the surface, volume, and dimension, based upon the sphere.

3. The observation of the relation between the *effective size* and the *theoretical size*, in terms of coefficients of this diameter in values to cover all influencing qualities or conditions of operation, or calculation or of performing tests.

Tungsten Mining and Milling

Underground and surface methods employed by a new producing company operating near Tucson, Arizona

J. B. Huttl
Assistant Editor

THE mine and plant of the Tungsten Alloys Corporation, a subsidiary of North American Mines, Inc., Boston, Mass., are 63 miles, by road, southwest of Tucson, Ariz., in the Las Guijas range, at an elevation of 3,100 ft. The company was the first to start again, in July, 1930, the active exploration of the tungsten deposits, which have lain idle for many years. Amado, a station on the Tucson-Nogales branch of the Southern Pacific Railroad, about 25 miles distant, is the nearest shipping point.

The ore occurs in shoots along dense quartz veins, embedded between granite walls, which vary from four to six feet in width and dip from 65 deg. north to vertical, with an east-west strike. In many places the granite is cut by basic dikes, resulting in zones of weakness along which the ore was deposited. These dikes, therefore, are of considerable importance in connection with exploration. As the tungsten ores are more resistant to oxidation and leaching than the sulphides, a good grade of tungsten ore was left in the oxidized areas.

Development of the property proceeded from an incline shaft, sunk to a depth of 80 ft., and three adits, known as Numbers 2, 3, and 4. Owing to the isolated situation of the various workings, every possible attention has been given to roads, surface plants and equipment, and ore-loading facilities. The air supply system is of particular interest. Air for underground operations at No. 2 shaft and Nos. 2 and 3 adits is obtained from a central compressor plant installed at the portal of No. 2 adit. To assure an adequate supply of compressed air in the event of a breakdown of the main air compressor, I-R portable gasoline-driven compressors, of 220- and 150-cu.ft. capacity. respectively, are maintained at No. 2 shaft and No. 3 adit. Adit No. 4 is served by an I.-R. portable compressor of 150-cu.ft. capacity.

Apart from the compressor installations, Nos. 3 and 4 surface plants also contain a change and tool room and a wooden ore-storage bin, so constructed that the ore can be dumped directly into the haulage trucks. The surface plant at No. 2 shaft consists of an ore bin, supporting the wooden headframe equipped with an automatic bucket-dumping device, and a 10-hp. Fairbanks-Morse gasoline hoist. Surface plant and equipment at No. 2 adit comprises a change room; gasoline-driven No. 2 Sturtevant centrifugal blower, connected to an 8-in. galvanized sheet-iron pipe system; 309-cu.ft. Chicago-Pneumatic oil-engine compressor and auxiliaries; blacksmith shop, containing a Sullivan Class C drill sharpener and an oil forge; a wooden ore bin; and a large water tank.

The ore is mined in open stopes supported by pillars, and, because of the solid walls and ground, a negligible amount of timber is required in stoping and drifting. Drifts, 5½x7 ft. in cross-section, are advanced with a 0.5 per cent grade. In drifting, all holes are drilled 4 to 4½ ft. deep, with lightweight Gardner-Denver Model 107 drifters, using 1-in. hollow round steel. An eighteen-hole drift round, as shown in the accompanying sketch, has been adopted. For stoping, Cochise No. 4 and I.-R.CA-31 drills are employed with 1-in. hexagonal hollow crucible drill steel. Lubrication of the drills is effected by means of line oilers which inject oil into the compressed-air lines. Forty per cent gelatine dynamite is used in both drift and stope blasting, with the usual cap-and-fuse practice, except in the breaking of unusually hard quartz, occasionally encountered, when dynamite of 60 per cent strength is employed.

Broken ore or waste is mucked manually into 1-ton end-dump cars, and trammed by the operator to the respective ore bin or waste dump. At No. 2 shaft the rock is hoisted to the surface in buckets of 1,000-lb. capacity, which are returned underground to the advance headings or stoped on small four-wheel trucks. This operation, however, will be discontinued as soon as the raise being driven from the No. 2 tunnel connects with the shaft tunnel 90 ft. above. All ore broken in the upper levels will then be dumped through this passageway and trammed through the No. 2 adit to the main storage bin.

Air for ventilating the advancing heading of No. 2 tunnel and raise is obtained from the centrifugal fan installation at the No. 2 surface plant. The shaft tunnel and adits Nos. 3 and 4 have natural ventilation. The mine is operated on a two-shift basis, with drifting and ore haulage done on contract. Ore from the stopes is trammed to No. 2 adit bin, which is equipped with two incline steel grizzlies, with 1-in. openings, to facilitate the hand sorting at this point. Both operations are performed on company time.

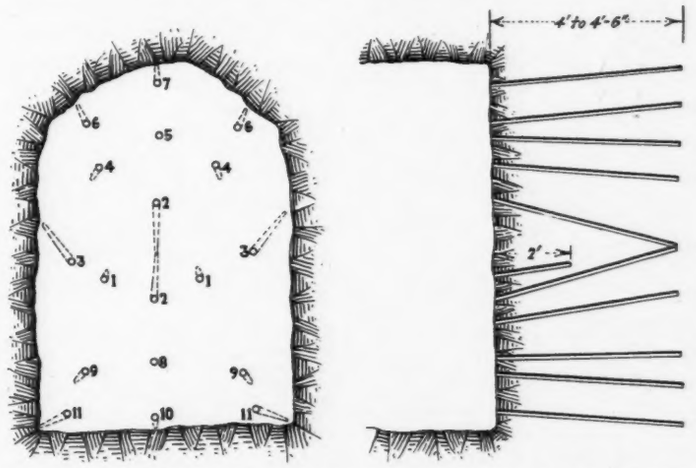


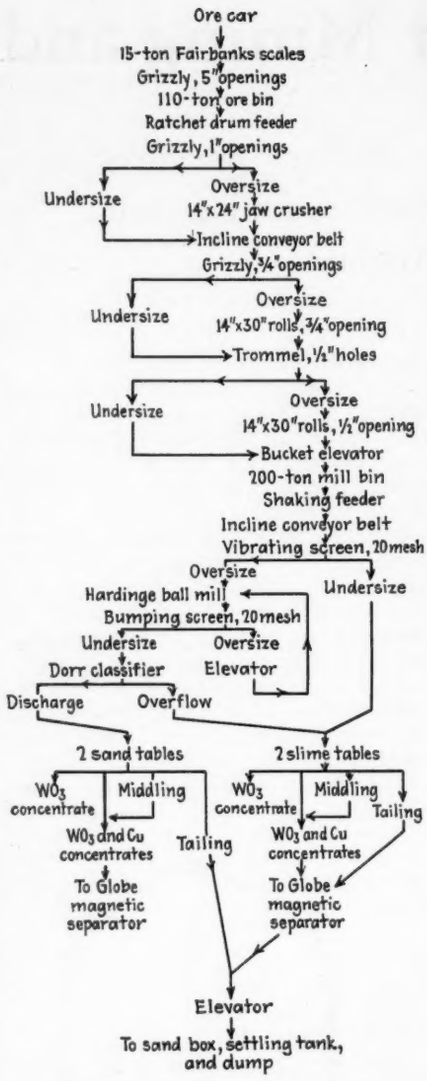
Diagram of eighteen-hole drift round; numerals indicate order of firing

From the various storage bins, 50 tons of ore is hauled daily in a 3-ton Ford truck to the mill, about a mile distant from the mine. The truck and contents are first weighed on a Fairbanks truck scales of 15 tons' capacity. Then, after passing up a 20-deg. incline trestle, the truck is dumped, the ore falling onto a steel grizzly made of 50-lb. rails. The undersize passes through the 5-in. openings into an ore bin of 110 tons' capacity. As shown in the accompanying flow sheet, a belt-driven ratchet drum feeder controls the

discharge of ore from the bin over a grizzly with 1-in. openings, the oversize going to a 14x24-in. Wheeling Molding & Foundry Company jaw crusher. Broken ore from the crusher and the undersize from the grizzly pass to an incline belt-conveyor, 117 ft. long, which discharges into a ¾-in. grizzly. Oversize from this grizzly comprises the feed for a set of Davis Iron Works 14x30-in. rolls that make a ¾-in. product. Undersize from the grizzly and the crushed material from the rolls then pass to a revolving trommel, with ½-in. punched holes. Undersize of the screen is discharged into an elevator sump, the oversize being crushed to ½-in. mesh in a second set of 14x30-in. rolls. A bucket elevator, containing a sampling bucket, then elevates the trommel undersize and the discharge from the rolls to the 200-ton mill bin. The sample bucket is fitted with a sheet-iron partition to facilitate dumping of its contents into a wooden flume connected to a Vezin sampler installation, driven by a 5-hp. Crocker-Wheeler Company motor, where a 1/15 sample cut is effected.

Power for the belt conveyor, jaw crusher, and drum feeder is obtained from a 25-hp. General Electric motor, and, for driving the two sets of rolls, the trommel, and the bucket elevator, a 25-hp. Westinghouse motor is utilized.

From the mill bin a shaking feeder discharges the ore into a short incline conveyor which feeds it evenly to a wet, minus 20-mesh, home-made vibrating screen. The undersize flows direct to a Deister semi-slime table, the oversize passing to a Hardinge ball mill of 20 tons' capacity per eight hours, charged with 4-, 3-, and 2½-in. forged-steel balls. A 20-mesh bumping screen receives the discharge of the ball mill, the undersize of the screen going to a single-rake Dorr classifier and the oversize returning to the ball mill via a small bucket elevator. The classifier overflow, in turn, flows to a second slime table, and the classifier sands to two fine-sand tables. Each of the four tables mentioned yields three products: concentrate, middling, and tailing. The middling, at present, is not re-treated, but is combined with the concentrate. Inclusion of the middling in the concentrate does not seriously affect the grade of the concentrate, which, after being dried, must first be cleaned at the magnetic separator at Globe, Ariz., because of the copper content and impurities.



Flow sheet of concentrator

Inasmuch as operations at the mill commenced the first week of January, or six weeks ago at the time of writing this account—a period insufficient to permit the possibility of securing and tabulating metallurgical data truly representative of the work the plant is capable of performing — approximate data only can be presented. The mill feed during this period assayed from 1½ to 2 per cent tungstic acid, and the tailing somewhat above 0.2 per cent. Recovery of metals averaged 80 per cent, with an over-all ratio of concentration of 25:1, resulting in concentrates containing about 40 per cent tungstic acid, which, after the final cleanup in Dings Magnetic separators, assay 60 to 65 per cent tungstic acid. The grinding limit of the mill is minus-20 mesh and the capacity of the crushing plant is twice that of the concentrator, which may be increased when conditions warrant such a change. The mill at the present time is operated on two shifts.

Concentrate, middling, and composite tailing samples are cut every hour from each table, in addition to the samples obtained automatically at the mill bin and grab samples taken at the mine. Because of the spotty and irregular concentration of mineral in the ore, large mine samples are necessary. All samples are treated at the well-equipped assay office, where facilities for wet and fire assaying are available. Crushers, pulverizers, and other laboratory machinery are driven by a 5-hp. Skandia Diesel engine.

The table tailing is first collected in a concrete sump, then elevated by a small bucket elevator and discharged into a wooden launder, equipped with a sand box to effect a separation of the sands. To recover the tailing water, the slime is directed into a settling tank, the overflow of which again is relayed to a reserve well 85 ft. deep. From this point the clear water is pumped back to the main supply well 45 feet deep. Water for milling operations is obtained from a 35,000-gal. tank, installed adjacent to the mill bin, which is fed automatically from the main well by an electrically driven centrifugal pump, with a capacity of 100 g.p.m. The grinding and concentrating sections of the mill are operated from the belt drive of a 125-hp. twin-cylinder Western oil engine, and power for the crushing plant is obtained from a 40-kw. 220-v. Western Electric generator, attached to the main drive shaft of the engine by a belt drive and friction clutch. The outflowing cylinder-jacket cooling water flows by gravity to the Dorr classifier, where it becomes part of the mill water circuit. Domestic water for the staff house, office, dormitory, recreation hall, and other camp buildings is supplied from a well 45 ft. deep, sunk along the large arroyo below the mill site. A Kohler power light plant furnishes electricity for lighting purposes.

Acknowledgment and appreciation are due Thomas L. Wells, superintendent, Tungsten Alloys Corporation, for the information presented in the foregoing account and for his permission to publish it.

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Fine crushing plant and incline conveyor from primary crusher

Kola Peninsula Phosphate Deposits

Dr. Leon Khvostovsky

AS A RESULT of extensive investigations into the ore resources of the Kola Peninsula, on the White Sea, carried on since 1920 by the Soviet Academy of Science, the fact has been established that the peninsula possesses one of the most important apatite deposits in the world. The Supreme Economic Council of the U.S.R.R. in December, 1929, organized the Apatite Trust to exploit these deposits and to erect plants.

The work of the Trust began in January, 1930, in the height of the Arctic winter. Production of apatite ore for that year was set at 250,000 metric tons, and for 1930-31 at 1,000,000 tons. Plans were also made for the construction in 1930 of a flotation plant with a capacity of 250,000 tons ot concentrates. To provide electric power, a hydroelectric station is under construction on the Niva River, with a capacity of 25,000 kw. Work on this station was started in October, 1930, and the plans call for its completion by the end of 1932.

The main center of the apatite deposits is in the Khibinsk tundras, situated in the center of the Kola Peninsula and extending over an area of 1,145 square kilometers. It is bounded on the west by Lake Imandra and on the east by Lake Umn-Yavr. The tundras are mountainous in formation, intersected on the eastern side by deep valleys and gorges and occasional rocky walls. The average height of the mountains ranges from 800 to 1,000 meters at Lake Imandra, 130 meters above sea level. Some summits reach a height of over 1,200 meters. Low-lying land around the Khibinsk tundras is marshy, with numerous lakes and fir trees. The mountains are devoid of vegetation, but the entire district is rich in ores and rare minerals, several of which are of considerable industrial importance. By far the most outstanding of these ores is the apatite-nephelite rock, found throughout the mountainous formations in varying thickness and quantities.

Three stations of the Murmansk main railway line (running from Murmansk to Leningrad) border on the western slopes of the Khibinsk tundras. During 1930 a network of railway branches was constructed, linking up the mines with the main line. Work is now proceeding to enable the branches to handle the traffic of twenty trains daily each way. Automobile roads connect the newly built city with the mining station, and other roads are being constructed to make connections with the Umba River, 20 miles to the southeast.

A chain of mechanical installations has already been erected to convey the ore from the mountains to the Loparsk Valley. The ore is either slid down the mountain side, which slopes at an angle of 35 deg., or by means of a hoist at an angle of from 9 to 12 deg., it is passed to platforms or loaded directly on railway cars. Automobiles also climb up the zigzag roads to the deposits to bring the apatite down the mountain side.

Khibinsk ores consist of nephelite-syenite of various compositions, forming two main types: (1) surface layers, consisting of khibinite (large-grained nephelite-syenite), composed of feldspar, nephelite, and egirin; (2) and the lower layers, which consist of small-grained nephelite-syenite, also containing egirin and biotite. Between these two main deposits apatite-nephelite ores are to be found. The apatite-nephelite resources now being exploited are in the southern sections of the Khibinsk tundras, where there are extremely rich deposits of nephelite, the so-called iolite containing up to 70 per cent of nephelite, and urtite containing up to 85 per cent of nephelite. According to estimates, the district has deposits containing about 5,000,000,000 tons of urtite, with over 1,500,000,000 tons of aluminum oxide.

Nephelite deposits are usually formed in the sediment of a volcanic mass during the period of mountain formation. This mass is rich in phosphates. The Kukisvum Mountain is so far the best-known center in the Khibinsk region for these deposits, which extend along the mountain at a height of 250 to 450 meters and for a distance of about 1,500 meters to the southwest and about 300 meters to the northeast.

According to investigations, the thickness of the layers of the Kukisvum Mountain deposits is as follows: (1) The upper layer has a thickness of from 50 to 60 meters and contains 75 per cent small-grained apatite, 20 per cent nephelite, and about 5 per cent of secondary minerals, such as egirin and magnetite; the estimated resources amount to 60 million tons. (2) The lower layer is about 130 to 140 meters thick and contains an average of 55 per cent apatite, 25 to 35 per cent nephelite, and 10 to 20 per cent of secondary minerals, the most important of which is titanomagnetite. Scattered ore deposits constitute about 40 per cent of the resources of large-grained apatite-nephelite, with a 75 to 80 per cent apatite content. The resources of this layer are estimated at 40 million tons.

The total quantity of apatite-nephelite deposits in other centers has not been accurately determined, but a preliminary estimate sets it at roughly 500 million metric tons. Prospecting is still being carried on, and the results attained up to the present have far exceeded expectations. Exact analyses of prospecting operations for P_2O_5 have given the following results: (1) The upper stratum has an average of 30.8 per cent P_2O_5 (20-32 per cent); (2) the lower stratum has an average of 22.5 per cent P_2O_5 (10 to 34 per cent).

Exploitation of the extensive apatite-nephelite deposits constitutes a problem of importance for the U.S.S.R. These new discoveries are expected to be of great importance for Soviet agriculture on account of their great value in the production of fertilizers, and for the Soviet chemical industry, which is undergoing a process of intensive development.

Hitherto, apatite has not been known as an important element in the production of phosphates. The small quantities procured in Canada and Norway have been mainly utilized in the chemical industry and for the production of pure phosphoric acid. The considerable resources of apatite-nephelite in Khibinsk raise an important scientific problem. Experiments are now being carried on in laboratory and plant by leading Soviet scientists, to determine their usefulness for industrial purposes.

Apatite is a crystal-like mineral containing phosphorus, calcium, fluorides, chlorides, and carbonates. In concentrating apatite-nephelite ores the following products are obtained:

1. Concentrate obtained from selective crushing. This consists of the smallest screenings from 30 per cent by weight of the crude ore, and has the following composition: phosphoric anhydride, 35-36.5 per cent; iron oxide, 1.8; aluminum oxide, 1.4; titanium oxide, 0.5 per cent.

2. Flotation concentrate from 40-45 per cent of the residue from crushing, which has the following composition: phosphoric anhydride, 28-37 per cent; iron oxide, 06-2.7; aluminum oxide, 1.4-5; titanium dioxide, 0.25 per cent.

3. Tailing after chlorination of crude ore, which has the following composition: phosphoric anhydride, 1-5 per cent; iron oxide, 5-9; aluminum oxide, 12-20; titanium dioxide, up to 2 per cent.

Methods have not yet been discovered as to the best way to divide this flotation residue, but so far the following prod-

ucts have been found: (1) nephelite, with a content of up to 1 per cent iron oxide, for glass making; (2) titano-magnetite, containing 15-20 per cent titanium dioxide, for the production of titanium white paint; (3) a last fraction containing rare elements.

Analysis of Kola Peninsula Deposits

	Per Cent	
	Poagvumgor Deposit	Rasvumgor Deposit
P_2O_5	41.21	20.85–16.24
CaO	54.92	29.73–27.03
Fl	2.75	1.03– 0.29
Cl	0.10	0.07–trace
SiO_2	0.83	23.86–10.89
TiO_2	.....	5.35– 0.79
CO_2	.....	1.08– 0.84
Fe_2O_3	.....	2.42– 0.49
Al_2O_3	.....	15.28–12.76
Radium metal group oxides	0.77	0.21–trace
MgO	.....	0.97– 0.68
FeO	.....	1.70– 1.20
MnO	.....	0.34– 0.13
Na_2O	.....	5.70– 5.34
K_2O	0.22	0.76– 0.69
Insoluble residue	0.54	.....

A method has been devised for the extraction of pure apatite from the apatite-nephelite ores for the purpose of manufacturing phosphoric acid and phosphate fertilizers. The utilization of the other minerals of secondary importance is also being subjected to an exhaustive study.

Nephelite, the other main constituent of the ores, contains alkali, silica, and alumina. The extraction of chemically pure nephelite is rendered difficult because of the presence of egirin, which so far cannot be completely eliminated. On this account nephelite cannot be used as yet in the manufacture of clear glass, but only for glass of a greenish color. The Drujnaya Gorka plant, in Leningrad, is planning the manufacture of glass from Khibinsk nephelite. Preliminary experiments have given good results, showing that the glass produced is less fragile than that produced from quartz. In the ceramic industry the use of nephelite as a substitute for feldspar has given favorable results.

Because of the presence of potassium oxide and its solubility in water, nephelite has given excellent results as a fertilizer. Further experiments are being conducted in order to obtain waterglass, silicate, alum, sodium sulphate, ultramarine, and alumina for the manufacture of aluminum. The success of this experiment would put the aluminum industry in possession of a very important source of raw materials. The Kola nephelite deposits are considerably larger than the apatite deposits. With the development of water power the Kola Peninsula may become an important center for the production of aluminum.

The titano-magnetite procured from the Khibinsk apatite-nephelite rock contains about 20 per cent of titanium dioxide, which can be extracted with little difficulty. Experiments with this mineral are being made in order to procure ferrotitanium and oxide of titanium with which to manufacture titanium white paint.

As already pointed out, there are in Khibinsk certain deposits which contain a high percentage of P_2O_5—from 32 to 34 per cent.

The experiments of Prof. S. M. Milovidov in the Chernorechensky plant show that apatite with an average content of 33.44 per cent P_2O_5 gives the following results: P_2O_5, 34.4 to 35.06 per cent; insoluble residue, 7.1 to 8.17 per cent; concentrates, 64.23 to 86-87 per cent.

Research carried on by Prof. S. I. Volfkovitch in the same plant shows that, from apatite with 34.9 per cent P_2O_5 and 8.7 per cent insoluble residue, superphosphates can be obtained with a 15 per cent content of P_2O_5.

In addition to the exploration carried on in connection with the apatite deposits, considerable work has also been done in a second circle of deposits. The Academy of Science established a mining station in the mountains, where periodic conferences were held during the first year. Besides apatite and nephelite, considerable deposits of albatite, magnetic iron oxide, pyrrhotite containing sulphur combinations of nickel and copper, and also deposits of pyrites, molybdenum, and feldspar have been located. The district also possesses vast peat resources.

The phosphates extracted from the Khibinsk deposits will be shipped in a raw state to Leningrad and other industrial centers of the Soviet Union, to be utilized in the production of superphosphates. Khibinsk apatite will constitute the main source of supply for the superphosphate industry. Estimates indicate that the phosphates from the Kola deposits can be delivered at a lower cost in Leningrad than the Morocco phosphates which the Leningrad phosphate plant has been using. To handle the Khibinsk phosphates, a treating plant is being constructed in Leningrad to be ready for operations early in the summer of 1931.

The reorganization of Soviet agriculture now taking place—by which the old system of individual farming on small strips and with primitive methods is fast being replaced by large collectively operated and state farms—will necessitate the supply of huge quantities of phosphate fertilizers. By the end of the Five-Year Plan (1933), 7,150,000 tons of soluble phosphates is expected to be used in agricultural districts. The estimated production by the last year of the plan is: Central Asia (Aktubinsk phosphates), 8,500,000 metric tons; Central U.S.S.R., 5,500,000 metric tons; Urals, 475,000 metric tons; Khibinsk apatite, 1,500,000 metric tons. These figures will probably be revised in connection with the growth of demand by increased requirements of collectivization, which has already far exceeded the original estimates.

Development of the superphosphate industry in the Soviet Union, on the lines indicated in the Five-Year Plan, will speed mining in the Kola Peninsula. The government assigned about 5 million rubles for the work to be accomplished during the first year of operations. As stated in the foregoing, the plan for 1930 was set at mining 250,000 tons of apatite ore, and for 1931 at 1,000,000 metric tons. By August, 1930, over 2,000 tons of the mineral had been exported. The Niva River hydro-electric station will provide the district with a plentiful supply of cheap power.

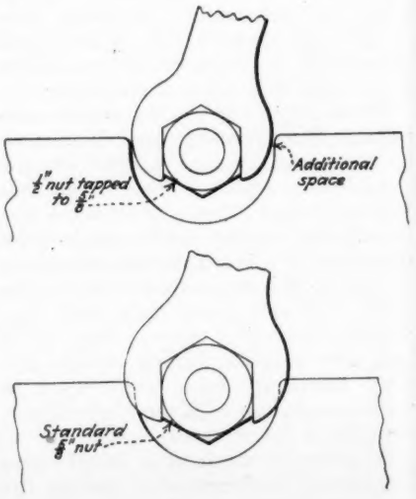
The work of extracting phosphates and establishing settlements for workers is hampered by the severe Arctic climate. During the first year an entire industrial city has grown up near the mines, within 20 kilometers of the Murmansk railway line. In a short time complete facilities will have to be created to provide for the settlement of from 12,000 to 14,000 people in a district which until a little over a year ago was inhabited only by one Loparsk family.

When the climatic difficulties are overcome, the Khibinsk tundras promise to become in the near future one of the most important mining centers of the northern part of the Soviet Union.

■

Tightening Nuts Without Special Wrench

BOLT or stud nuts on machinery, accessible only with special wrenches, may cause considerable difficulties and delays if no such tools are available to the repair man. To overcome this inconvenience, and make it possible to use regular wrenches on nuts in inconvenient places, the method shown in the accompanying sketch has been successfully applied by Thomas C. Hulton. Without particularly weakening the machine parts, $\frac{5}{8}$, $\frac{3}{4}$, or $\frac{7}{8}$-in. nuts may be replaced with $\frac{1}{2}$, $\frac{5}{8}$, and $\frac{3}{4}$-in. nuts, tapped to $\frac{5}{8}$, $\frac{3}{4}$ and $\frac{7}{8}$-in., respectively, thus providing additional space to use, with ease, any standard wrench. The same procedure can, of course, also be applied to nuts of other sizes than the aforementioned.



Cut-and-Fill Stoping

Morris J. Elsing

USE of the cut-and-fill method of stoping is universal, but so far as production in the United States by the six principal underground mining methods is concerned, it stands at the bottom of the list. It is one of the higher-cost methods, and cannot be classed as a particularly safe one. Improvements have been made from time to time which have cut the cost per ton, and a better understanding of ground conditions has made it safer. The purpose of this paper is to make general comparisons between the horizontal and incline methods and to discuss some of the improvements and variations in applying the method.

When much sorting is required, the incline method cannot be used successfully. The Baltic lode, in the Michigan copper country, is a good illustration of this. At the Baltic, Trimountain, and Champion mines the lode dips about 70 deg. and is about 20 ft. wide. The waste in the lode breaks in somewhat larger tabular pieces. The sill floor is cut out for the width of the lode and 16 ft. high. On either side of the track, dry rock walls are built up for the height of the drift by using these tabular waste slabs. Timber is then placed across these walls, which are 7 ft. 6 in. apart, and rock chutes are built up. The stope receives a charge of waste, which is leveled off, and another horizontal slice is taken out. Mill tailing and stamp sands are used for filling, supplementing the waste from development work. Often a slice is shot down for 50 to 100 ft. along the lode and left in the stope because it is too low in grade to treat as ore. Fill costs 50c. per ton, and if any part of the lode carries insufficient mineralization to pay for handling, tramming, hoisting, and milling, and show a profit of more than 50c. per ton, the material is worth more as fill than as ore. At the Champion mine, only 65 per cent of the total rock broken in stopes goes as ore. Obviously, under such conditions the incline method would not be feasible. When the horizontal stope nears the one worked out on the level above, an incline variation is employed, which involves mining the last 20 ft. vertically. Cribs, bulkhead, and stulls are used generously, and the stope is holed through to the old stope above at the farther end of the one being worked. The waste fill then caves into the stope and the 20-ft. pillar is taken out in incline slices, the men working on the waste in the same way as in the typical incline cut-and-fill stope.

At the Elisa mine, at Cananea, Mexico, much the same relation of ore and waste makes the horizontal method the more satisfactory of the two methods. The ore in this mine occurs as chalcopyrite in garnet. To maintain a smelting grade, it has long been necessary to sort most of the ore carefully. Starting a stope in this mine was often a piece of prospect work. If a drift passed through a few feet of garnet limestone containing chalcopyrite, it was customary to cut out a sill floor stope to see if a satisfactory grade of ore could be obtained by sorting. Even if the results were only fairly satisfactory, a second floor was taken out, and so on. Not uncommonly the roof of the stope was shot down and most of the material allowed to remain as fill. If a stope were shut down in every case where it showed an operating loss, all stoping in the mine would soon have been suspended. Only by constant attention to the grade of ore, by selective mining and sorting, was the mine kept operating. Faith that a lean slice or two would give way to higher-grade ore was nearly always rewarded, and the Elisa mine has had a longer life than most of the other mines in Cananea have had. In most respects the horizontal cut-and-fill method was ideal for this property—possibly the only one that would have permitted operation at a profit.

The Lucky Tiger mine, El Tigre, Mexico, also illustrates the advantages of the sorting which can be done in a horizontal stope. The vein averaged 1.7 ft. wide and the average stoping width was 3.4 ft. In some instances, ore and waste were blasted separately in the horizontal stopes. In view of the very high grade of the ore, ore and waste were blasted together on cowhides, the coarse waste was sorted out, and all of the fines were loaded as ore. The walls were shot in for fill. Where the vein was narrow and the walls were soft the horizontal method worked well. The incline method could be applied only where the vein was wide and the walls were fairly good and the ore required little or no sorting.

The incline method permits a small amount of sorting, but when ore conditions are such as occur in the three mines mentioned, it cannot be applied.

Comparison of the two methods on the basis of safety shows some difference of opinion. That the arching effect secured in the incline stopes is theoretically safer for the roof than having it horizontal is generally conceded. However, there is a limit to this, as at Cananea. Here multiple stopes are worked and it has been impossible to give the stopes a sufficiently steep incline so that ore will slide into the chutes. The belly over the chutes between two such stopes has been found too great to permit working by the typical incline method. Scrapers are used for delivering the ore to the chutes, and thus a part of the benefits of applying this method has been lost.

Two outstanding successful examples of the incline method are the Iron Cap, at Globe, Ariz., and the Calumet & Arizona, at Bisbee. At the former, a large part of the total tonnage mined was from incline stopes, whereas at the latter mine about 65 per cent of the tonnage is now being produced by the cut-and-fill method and most of this by modified incline methods.

On the other hand, almost the entire tonnage from the United Eastern, at Oatman, Ariz., came from horizontal stopes. The incline method was tried, but, because of the tendency of the vein to slab off, was found unsuitable. At the United Verde, at Jerome, about 65 per cent of the tonnage comes from horizontal cut-and-fill stopes and only a small amount from incline stopes. The incline method was not found adaptable, because the ore tended to shatter ahead of the point where it was being blasted, so that working under the brow was dangerous. Because of this characteristic of the ore it is broken in horizontal stopes by drilling flat holes with drifting machines, which leaves the roof in a safer condition. At Nacozari, Mexico, the incline method is held in high repute and is employed wherever possible, but the horizontal method produces 60 per cent of the total, as against about one-third of this amount from the incline method. At the Pecos mine, New Mexico, the incline method was tried and rejected because of danger to the workmen. Placing cribs, bulkheads, and stulls was difficult, and the horizontal method was found more suitable. At Broken Hill, Australia, at Zaruma, Ecuador, at Santa Gertrudis, Mexico, and at Matahambre, Cuba, the horizontal method is preferred to the incline.

To maintain safe working conditions necessitates that the cut-and-fill method be applied only to the ground that stands best. In general, the wider the stope the more dangerous does it become, so that the width must be lessened when the ability of the ground to stand is reduced. The safety provided in arching the roof of a stope is generally recognized and

applies equally to square-set stopes as well as to those of other kinds. In most incline stopes the single incline affords the greatest safety and the multiple incline the least. Under certain conditions of fracturing, sheeting, faulting, and bedding, the single incline may be safer if laid out in one direction rather than in the opposite. Close inspection of the roof makes for safety, and the easier the inspection can be made, the more thorough does it become. Generally the horizontal stope is conceded to have the advantage in this respect. On the other hand, in incline stopes the men work in the safest part while the ore is being drawn, and, where the square-set modification is used, they work under timber part of the time.

Where bulkheads and cribs are needed to support the roof these are put in and removed from the horizontal stope with less difficulty. That they are more often used in the horizontal stopes naturally follows.

The horizontal method is in general held to be safer than the incline method, I think. Production from horizontal stopes greatly exceeds that from the incline. In large measure, this is due to the advantage of sorting which the horizontal stope permits, but the greater safety of this type of stope is certainly a factor in bringing about its wider use.

Square-setting is employed as an important auxiliary method in many mines where cut-and-fill methods are used. This is nearly always so when the 15- or 20-ft. block just below a worked-out stope on the level above is taken out, but does not always apply to narrow veins, as other more simple means of support can be found.

In some operations as much as 30 per cent of the tonnage from a cut-and-fill stope comes from the square-set portion. At Matahambre, in 1928, the square-set stopes produced 30 per cent of the total tonnage. In this mine, square-sets are always used in mining the last 15 or 20 ft. of the orebody when making connection with the level above. The cut-and-fill stope on the latter level having been started 14 ft. above the rail, there is a vertical section of the lode, 29 to 34 ft. high, to be mined by square-setting. This is a disadvantage of the cut-and-fill method. Square-setting, when thus done, cannot always be employed to the best advantage. Sets must be stood on unconsolidated fill, and ore chutes often are not spaced advantageuosly. Conditions of size and shape do not usually lend themselves to the most economical square-setting. However, no alternative method has been devised for mining this section of a large orebody.

Modified cut-and-fill methods are becoming more and more important. At the Calumet & Arizona mine, several such modifications, in which square-sets play an important part, have been developed. In the so-called double-lead incline method, as much as 20 per cent of the ore is extracted by square-sets, whereas in other modifications a lesser amount is mined by square-sets. At the Magma mine, Superior, Ariz., a combined square-set and incline-cut-and-fill modification is employed.

Square-setting is the most common method of mining the pillars left between cut-and-fill stopes. Some of the functions of square-sets are shown in the accompanying figure and the relative proportions in the following table.

These figures show how large a tonnage comes from square-sets used in conjunction with cut-and-fill methods. In some instances 60 per cent of the ore in the combined stope and pillar is mined by the square-set method.

Personal experiences with different cut-and-fill methods are the basis of the following observations. More serious accidents occur in cut-and-fill stopes than in any other class of stopes, in my opinion. These are more likely to happen in medium-sized irregular orebodies than in the larger ones or in comparatively narrow veins. When large orebodies are being mined, definite stopes and pillars can be laid out, and, as these are carried up, they will not increase in size. In mining the irregular, medium-sized orebody, when the outline of the body is definitely known on the level where started and on the level above, decision is often made to take out the whole orebody without pillars. In such event, if there is an increase in size between levels, the temptation to open up too much ground is great, especially where the enlargement is too small to warrant pillars and an additional section. Often a stope which is really too large can be worked out without a cave, but this is not always true. Caving, however, is not confined to large stopes, inasmuch as V-shaped blocks or slabs often cave away from very insignificant slips.

Bulkheads, cribs, and stulls are commonly used to support the roof of cut-and-fill stopes. A generous number of cribs in a large stope certainly give a sense of security, but often this is more imaginary than real. In the first place, this timber is resting upon unconsolidated gob; and even when a plank foundation is first laid, the footing is far from solid. In horizontal stopes, when waste filling is being put in, cribs are taken from the lower level to the new fill level and placed on the edge of the fill, which is soft and insecure as a foundation. To act as effective support the bulkhead must be wedged securely against the roof of the stope. One such wedging is not sufficient, as the waste filling sinks slowly and wedges quickly become loose, so that the bulkhead or crib actually supports nothing. Proper attention to wedging of stulls is not overlooked as often as the wedging of bulkheads, because stulls will fall over of their own weight if not properly wedged, which is not true of bulkheads and cribs. Both are effective in holding up small slabs and boulders, but in either circumstance the preferred practice is often to bring such ground down immediately without attempting to hold it up.

Both from the character of their foundations and the breaking strength of the timber, I am not certain as to exactly what value to place on such timber as a means of support to any really heavy loads. To have any real value, wedges must be tight, and this

Auxiliary Methods of Stoping Employed With Cut-and-Fill Method

Dimensions A, B, C, and D Shown in Accompanying Sketch

Mine	A. Vertical Height (Ft.)	Method and Remarks	
Calumet & Arizona	10	Square-set.	Mitchell.
Cananea	11 to 22	Top-slice.	
Magma	0		Sill floor out.
Matahambre	14	Square-set.	
Nacozari	20	Square-set.	
Pecos	20	Square-set.	
United Eastern	0		Sill floor out.
United Verde	24	Square-set.	
	B. Vertical Height (Ft.)		
Cananea	15	Square-set.	
Champion	20	Incline cut-and-fill.	
Magma	15–20	Square-set.	
Matahambre	15–20	Square-set.	
Pecos	20	Square-set.	
United Eastern	15–20	Cut-and-fill; crib support.	
United Verde	15	Square-set.	
	C. Width of slope (Ft.)		
Calumet & Arizona	45		
Cananea	30		
Magma	16		
Nacozari	30		
United Verde	10–160		
	D. Width of Pillar (Ft.)		
Calumet & Arizona	45	Cut-and-fill	Mitchell.
Cananea	50	Top-slice.	
Magma	14	Segment-sets.	
Nacozari	30	Square-set.	
Pecos	15	Square-set.	
United Verde	35	Square-set.	

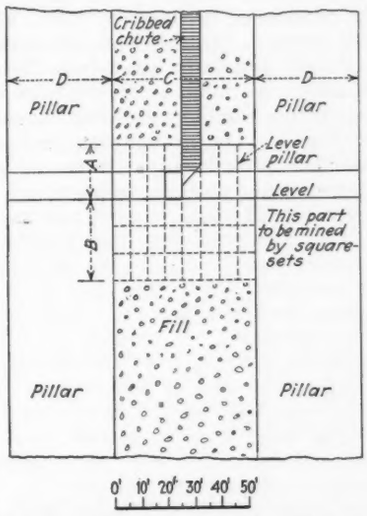
requires close inspection. Under certain conditions, this inspection should be made daily, at least, until the waste filling has become more or less compact. I believe that a properly wedged crib has a steadying effect on the roof of the stope, but its capacity to support a great weight is more imaginary than real. Without question, the presence of a large number of cribs has a psychological effect on those in the stope, and for this reason alone they are worth while. In addition to this, they will prevent a sudden cave, or will warn of an impending cave, and will hold up small key pieces. In this last they are performing their most important function.

As to the elevation of the sill floor, modern practice has been to open up the bottom floor of the stope at some elevation above the level. Sometimes this is done at 8, 9, or 11 ft. above the level or perhaps at double these distances. The object in doing this is to keep the level extraction drift in solid ground. In some instances, this means that the level drift need not be timbered. If the sill floor is taken out on the level, timber must be used. The weight of the gob upon this timber gives trouble sometimes in that, as the stope advances, repair work becomes necessary. The point for consideration is the method to be employed in mining the ore below the level; also the ore below the cut-and-fill to be started. In mining large orebodies, the most common method is square-setting or, less often, top-slicing. When the latter method is to be used, the elevation is 11 or 22 ft. or a multiple of the height of the slice floor. When square-sets are to be used, this elevation is a multiple of the height of the square-sets. If the orebody below the level is to be mined by cut-and-fill, the upper part is mined by square-sets (see the sketch). These are brought up to the level and then carried on up to the bottom of the cut-and-fill stope. Under such conditions I think there is some doubt as to the advisability of opening the stope above the level.

If 15 or 20 ft. of the orebody below the level is mined by square-sets and 15 to 20 ft. above the level, this makes from 30 to 40 ft. out of 100 ft. to be mined by square-sets. Under such conditions 30 or 40 per cent of the orebody is mined in this manner. The latter figure is unusual, perhaps, but to get 30 per cent of the production by square-sets is not uncommon. One must always remember that this square-setting is not done under the most favorable conditions, and costs, in consequence, are higher than normally.

If the cut-and-fill stope is started on the level, the extraction drift can be placed under the edge of the pillar and there will be solid ore overhead. This has been successfully done. Under such conditions, the sill-floor timbers are subjected to side pressure only and repairs are unimportant. This procedure will reduce the amount of square-setting, which is a decided advantage. The total cost per ton is the cost per ton of the cut-and-fill ore and of the square-set ore. The former method is cheaper, and, consequently, the larger the proportion of ore that can be won by it, the lower the total cost will be. In other words, lower total costs will nearly always obtain if the amount of square-setting is reduced to a minimum.

A minimum amount of timber is used by cut-and-fill methods. However, under certain conditions a considerable amount is needed. This includes chute and raise timber, which



Cross-section of stope and pillar to illustrate the function of square-sets in modifications of cut-and-fill stoping. See table.

cannot be recovered. There is also floor timber upon which the ore is shot. This is recoverable, but the breakage is high, especially where the ore is hard. Much of the timber in cribs, bulkheads, and stulls is recoverable. If the stope is bounded by ore pillars, side lagging must be used. Numerous ways of placing this have been discussed, none of which are entirely satisfactory under all conditions. This side lagging is required to hold the waste filling in place when the adjoining stope is being mined, and in many instances it does not do so. The amount of trouble experienced from this source depends mostly on the character of the waste fill put into the stope. If the fill tends to pack, solidify, and possibly to cement, little trouble will be had by fill running into the new stope. Certain gobs become so hard sometimes that to make them cave requires blasting. This condition is ideal and could it be known that such a result would obtain, side lagging could be dispensed with advantageously. The greatest difficulty results when gobs are dry and do not pack. Care must be exercised in blasting the ore alongside of them for fear of starting a run. Under some conditions when a run really starts, to stop it is difficult and it usually gives trouble when mining succeedingly higher sections of the stope.

When mining a pillar between two cut-and-fill stopes, nothing is more annoying than to have gob runs on both sides of the stope at the same time. To have such a thing happen does not necessarily indicate poor mining. When stoping the ore alongside of loose, unconsolidated gob, the utmost care cannot always prevent these runs from occurring. They are undesirable for two reasons: first, because ore and waste get mixed, with the result that waste gets into the ore chute and some ore is lost in the waste fill; second, because a run is likely to disarrange gob lagging higher up and so is likely to be repeated when mining this particular part of the stope on the next higher floor. To have repeated runs of fill is undesirable, as they will end in forming large openings somewhere above, which may be the cause of increased difficulties in mining ore higher up or even cause serious caves.

One common method of putting in gob lagging or building gob fences is to place stringers and lagging against the pillar to be mined. One end of an old cable is fastened to the stringer and the other end to a large block, which is buried in the gob. This block acts as an anchor which holds the stringer and lagging in place when the ore against which it rests is being mined. When stopes are not too wide, cables are run across the stope from side to side and thus hold stringers in place on opposite sides of the stope. This procedure is quite satisfactory except that it is accomplished at considerable expense.

One of the factors which has brought about the introduction of modified methods of cut-and-fill has been the difficulty of gob runs. A common method is to carry up a line of square-sets on both sides of the stope. These act as chutes and also provide substancial gob fences when the next section is mined. This arrangement has been applied to both horizontal and incline stopes, and although it requires considerable timber, costs are reduced. Several variations of this method have been devised at the Calumet & Arizona mine, and most of the ore in the new Campbell mine is now being produced by their means.

Where ground conditions permit, one of the most successful modifications from the viewpoint of cost is a combination of shrinkage and cut-and-fill methods. This has been termed semi-shrinkage at the Calumet & Arizona, and is used in incline stopes. It has also been used at Nacozari in incline stopes and at Cananea in horizontal stopes. It is applicable only to the best-standing

ground. Where it can be used, numerous advantages result. The expense of laying plank flooring and of the breakage of flooring can usually be cut in half. The cost of spreading gob is reduced greatly and less ore is lost in the gob. Loss of ore in the fill is sometimes quite serious, as at Santa Gertrudis, where it has been found that old fills have been sufficiently profitable to warrant re-mining by top-slicing. Such a condition also applies to other methods.

The ideal mining condition for the cut-and-fill method is where the orebody is sufficiently small to make dead lines and pillars unnecessary or where the vein is not too wide to mine the whole of it at one time with stopes running with the vein. Where the whole orebody can be taken out at one time, side lagging is unnecessary, and in veins, if the ore and waste stand well, pillars can be reduced to a minimum. Under such conditions, where the ore requires little or no sorting and the walls are good, the incline method gives the lowest costs. The most favorable conditions for applying the cut-and-fill method are similar to those necessary for shrinkage mining, and when they prevail, the shrinkage method of mining is cheaper than the cut-and-fill, even if subsequent filling is required.

Device for Controlling Flow From Mine Dams

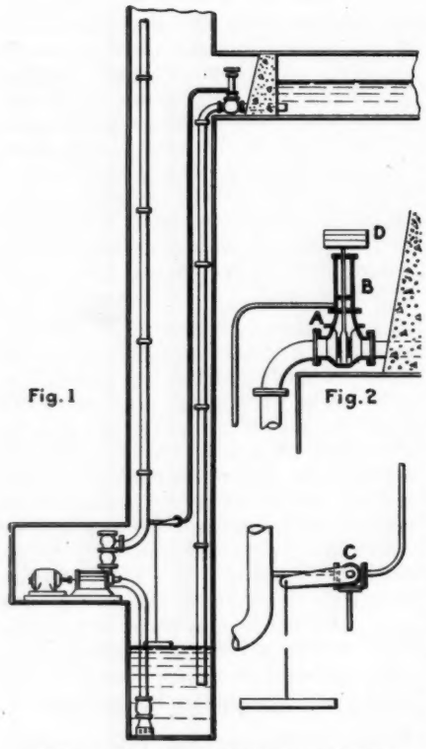


Fig. 1

Fig. 2

Figs. 1 and 2—General arrangement of dam, sump, and control mechanism

RECENT INNOVATIONS at the Settlingstones mine, Northumberland, England, as described by G. Trestrail in a paper presented recently before the Institution of Mining and Metallurgy, London, include, first, an arrangement for providing increased water storage at the central pumping station, to safeguard the pump units from flooding in the event of a pump failure or a sudden abnormal inflow of water; and, second, a method of mechanically controlling the flow of water from the mine storage dam to the pump sump. The pumping equipment consists of two centrifugal pumps of 600 to 650 g.p.m. capacity, driven by a 160-hp., 550-volt motor, which are operated alternately for short periods, to guard against humidity penetrating the armatures and to keep the motors in good running order in general. To maintain a constant, even flow of water to the pump sump, a dam was built in an abandoned level, about 30 ft. above the sump. Into this dam the bulk of the inflowing drain water from the surrounding workings is diverted for storage before reaching the sump, as shown in Fig. 1. The storage dam and sump together provide from seven to eight hours' water storage, sufficient to perform needed pump or pipe repairs.

For synchronizing the water discharge from the dam to the pump sump in accordance with the capacity of the pump, the arrangement shown in Fig. 2 was developed. It consists of a 5-in. pipe line, leading from the dam to the sump; gate valve *A* and cylinder *B;* a ¾-in. pipe line, with a three-way cock *C* and level float attachment, connecting cylinder *B* and the main pump discharge column; and weight *D*. The gate-valve spindle is directly connected to the piston operating in cylinder *B*, the stroke of which equals the lift of the valve. The flow of the water from the dam is controlled by the float attachment, according to the rise and fall of the water level in the sump, which may be explained as follows: When the water in the sump recedes, the float actuates the three-way cock, establishing a pressure in the cylinder above the gate valve equivalent to the static head of the discharge column, which is more than sufficient to keep valve *A* open and permit the water from the dam to flow into the sump. When the water flowing into the sump is in excess of the pump capacity and has risen to a predetermined height, the float again comes into action, opens the opposite aperture of the cock *C*, and releases the pressure from the cylinder *B* and the discharge column, thus allowing weight *D* to close valve *A*.

The indicator, installed at the power station, with which the operator can ascertain the exact water level in the sump, is also of interest. This apparatus, of simple design, as shown in Fig. 3, consists of a grooved wheel over which is placed a flexible steel wire attached to a ball float and counterbalance. A lever arm, fitted to the spindle of the wheel, which is mounted on a wooden frame, actuates a control brush, which, in turn, contacts with the copper terminals, arranged in a circle on a board attached to the frame and spaced at the equivalent to a float movement of 6 in. These terminals are respectively connected to Leclanché cells in series, with negative mains to earth. The battery current from the terminal is communicated through the brush, first to a circular plate, also attached to the board, and then passes through a wire main to a low-reading voltmeter, the dial of which is graduated to represent each 6-in. rise or fall of water in the sump. A press-button switch, which is closed when a reading is required, is provided on the main wire connected to the voltmeter.

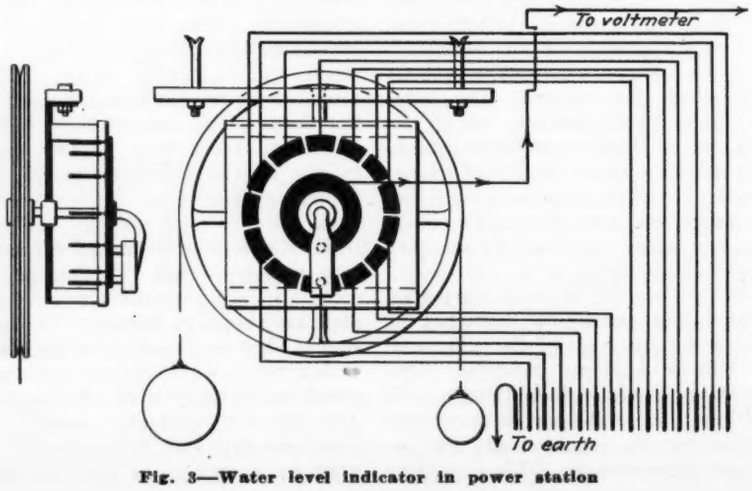


Fig. 3—Water level indicator in power station

Upkeep of Electric Locomotives

Re-babbitting and Packing Bearings—
Care of Detail Electric and Mechanical Parts

John S. Dean

WHEN circumstances indicate the advisability of re-babbitting bearings the following points should be given consideration:

1. Shells should be thoroughly cleaned.

2. Tin the shells in the bore before relining.

3. Use a high-grade tin-base babbitt metal.

4. Bearing shells and mandrels should be heated before re-babbitting.

5. Babbitt metal should be well stirred before pouring.

6. The babbitt metal should be poured while at a temperature of from 460 to 480 deg. centigrade (860 to 896 deg. F.).

7. Give all babbitted shells a sound test by striking with a hammer. Those that give out a clear, bell-like tone are good; those that sound dead should be set aside and re-babbitted.

Best results are obtained in babbitting by the use of pots heated by electricity and fitted with automatic temperature control, properly to regulate the temperature of the metal while it is being poured.

Bearings should be properly packed and carefully and systematically lubricated. In this connection the following should be considered:

1. Use a good grade of long-strand wool waste to pack the sleeve-type bearings.

2. Use a high-grade car oil, summer and winter grade.

3. Journal bearings, if properly packed with thoroughly saturated waste and protected from dirt and water, should not need any free oil.

4. Pack bearings of the sleeve type (side feed) by using a wick or long fibre-wool waste extending from the bottom of the oil well to the bearing window. Pack up the wick by tamping waste in the waste chamber to keep the wick forced up against the journal at the window.

5. Axle bearings, top feed, require oiling every morning.

6. Axle bearings, oil and waste, side feed, if properly packed and protected from dirt and water, require oiling every seven days.

7. Armature bearings, sleeve type, top feed, require oiling every morning.

8. Armature bearings, sleeve type, oil and waste, side feed, require oiling only every seven days.

9. Lubricate the armature ball bearings with an approved grease, and not with oil.

10. Ball or roller bearings should be lubricated about every eight weeks, if properly protected from dust and dirt. The grease or oil level should be just above the top of the lowest ball or roller.

That considerable damage may be done to the commutators of mine locomotive motors by the use of too much oil in the commutator and armature bearing is a recognized fact. This should be guarded against.

To reduce trouble caused by loose pinions, arrange to heat them in boiling water for about one hour, and, while hot, drive them on the shaft. A buffer made of soft metal should be held against the pinion to protect it while driving it on with a sledge. A suitable pinion puller should be used to remove worn and damaged pinions from the shafts. The use of the "wedge-and-sledge" method often damages housing, bearing, and shaft.

Various worn and broken parts of the equipment on mine locomotives can be reclaimed with considerable saving of time and money by the use of electric welding. On the other hand, there is a tendency to carry this practice too far by attempting to make repairs on some parts that are likely to break and give trouble in service. Some operators have attempted to build up worn bearing seats on the armature shafts of their mine locomotive motors, and, after unsuccessful results, have discontinued this practice. Welding of worn pinion key seats or damaged pinion nut threads on axle steel shafts has been successfully done. However, I advise against against welding of any kind, on shafts made from heat-treated axle or alloy steel, because this practice destroys the treatment of the material and will cause the shafts to fail in service.

To keep the detail electrical equipment in good operating condition is important, because failure of anyone of these parts seriously handicaps the operation of the locomotive as a unit.

Clean the inside of the controller, removing all carbon dust and dirt; then paint the insulation with shellac or a special insulating compound. Carefully smooth up all contacts and segments, using a fine file, and then lubricate them with a thin film of oil. Average pressures most generally used with the old type of fingers are as follows:

Width of Finger, Inches	*Pressures, Points*
1	8
¾	6
½	4

These pressures should be checked by a small spring balance. With the new compensating-type of finger developed for some of the drum-type controllers the pressure should be maintained at approximately 60 per cent of the values given above. Repaired controllers should be given the same voltage test as that recommended for rewound armatures.

The fuses most commonly used are the copper-ribbon type mounted in a specially designed box. These standard ribbon fuses are rated at one-half the current at which they will blow in 30 seconds. In applying a fuse, select and use one with a continuous current rating at least equal to the continuous duty imposed upon it. Keep the inside of the box clean, and be sure that the fuse is securely clamped in place and of the proper size to protect the equipment.

When circuit breakers are used, see that they are overhauled at regular periods and tested for grounds at the same voltage as recommended for rewound armatures. See that all contacts are cleaned and filed smoothly and then properly adjusted. Lubricate the tipping mechanism with a little light oil to make work freely. See that the blow-out coils are put in good repair and well insulated. Check and adjust the setting of all circuit breakers about every six to eight months, using an ammeter.

Locomotives operating above ground should be provided with lightning arresters to protect the equipment during electrical storms. Connections to the arrester, and from the arrester to ground, should be made as short and straight as possible. Arresters should be inspected regularly, the time of in-

spection to be based on the type of arresters used. Especially after each storm, all arresters should be inspected and put in good working condition.

The grid resistors should be kept thoroughly cleaned of all dust and dirt. Tighten up the tierod bolts and lead connections and replace all cracked or broken grids by new ones. Use only grids that are accurately ground at the contact on the bosses, and that have the correct ohmic resistance values. Give all repaired resistors a ground test similar to the test recommended for rewound motors. These tests should be made from each tierod to the end frames; also from each tierod to the grids.

A new type of resistor has been developed and is being used to replace the old cast grids on a number of locomotives. These individual resistors are made from a high-resistance metal ribbon, wound edgewise and mounted on porcelain supports which in turn are supported on a flat steel rod.

When replacing a trolley wheel, always use a new axle pin, or see that the old one is in good working condition. Keep these bearings in good condition, because much wear will tend to cause jumping and pounding of the wheels. The phosphor-bronze contacts on the harp should be kept in good condition and make full contact on the side of the wheel. The trolley wheels most commonly used are 4 to 5 in. in diameter and are made from a bronze alloy containing at least 90 per cent of copper. All wheels should be carefully machined and well balanced to minimize pounding on the overhead trolley wires. Pole-socket axle pins and all other moving parts must be kept well lubricated. The tension on the trolley base should be adjusted to get about 15-lb. pressure on the wheel at the trolley wire.

All detail parts of the headlights, and of the resistors when used, must be kept in good repair. When lamp replacements are made, care should be taken to use lamps of the same wattage as the ones being removed. Thoroughly clean the inside of the lamp frame, especially the reflector, and see that all covers are tightly fitted and so sealed as to protect properly the lamp globe and reflector from dust and dirt.

All worn or damaged detail mechanical parts of the locomotive frame should be repaired or replaced by new ones. On locomotives equipped with leaf springs, apply a small amount of oil from time to time to the top half and permit it to run down the sides where it will eventually creep in between the individual leaves. Examine the journal box springs at least once a week and replace any which may be cracked or broken.

The wheels, which may be cast iron with chilled treads, steel tired, or solid rolled steel, are pressed on high-grade forged-steel axles. The pressure required is about 10 tons per inch of the diameter of the bore of the axle fit in the wheel, and, with these pressures, keys are not required. Cast-iron wheels should be replaced when worn through the chill. All-steel wheels should be turned down in a lathe when the tread becomes badly worn. These wheels should be turned before they begin to cause damage to the tracks. A wheel damages the tracks at the switches, frogs, and curves at about the same time it reaches its limit of wear and requires turning or replacing with a new one.

Journal boxes of electric locomotives are usually made of cast iron, and on certain types of locomotives are so constructed that the end thrust of the axle is taken by a brass wearing plate mounted on the inside of the lid. This design when properly maintained prevents the wear at the wheel hub. When the thrust plate and journal brasses are worn badly they should be replaced by new parts. Neglect of these parts will cause rapid wear and final destruction of the journal boxes.

The brake rigging, which is one of the most important parts of the locomotive, should be kept in continuously good working order. All parts should be regularly and systematically inspected and the worn and defective parts put in good condition or replaced by new parts. As safe operation is dependent largely on good brakes, they should be frequently adjusted and overhauled to insure the proper braking action.

The sanders should be kept in good repair and the openings or outlets kept free to insure a quick application of sand when needed to prevent the slipping of the wheels.

Further to improve the operation of mine locomotives and to minimize their failures, which precaution assures a larger output of coal or ore, attention should be given to the following:

1. Keep the roadbed for the tracks in good repair.

2. Align and secure all rails to the ties.

3. Special care should be given in bonding all rails at the joints.

4. See that the overhead trolley is properly maintained.

5. Experienced and carefully trained locomotive drivers or operators are essential.

■ ■ ■

Repairing a Cast-iron Oil Filter Jacket

IN THE power station of Sociedad Minera y Metallurgica de Penarroya, at Puerto Llano, Spain, a constant loss of lubricating oil was experienced with an 8,500-kw. steam turbine. A careful inspection of the entire unit during a brief shutdown led to the discovery of a fine crack, about 9 in. long, in the vertical oil filter jacket, shown in Fig. 1 of the accompanying illustration. Cracking had been caused by excessive and uneven tightening of the nuts of the stuffing box by an inexperienced operator. With no spare parts on hand and but a limited time available, a method of repairing the damaged jacket in the shortest possible time had to be found. Acetylene or arc welding was inadvisable on account of the delicate construction of the shell and the danger of deformation. The following method, which was entirely successful, was therefore used:

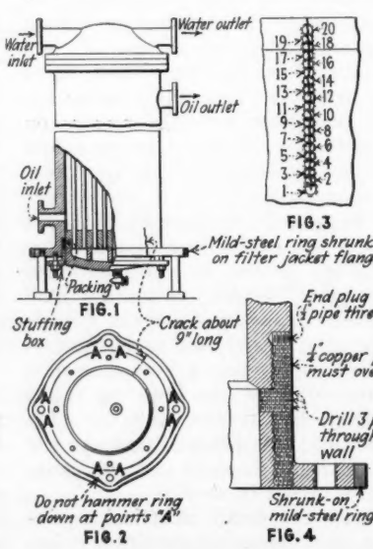
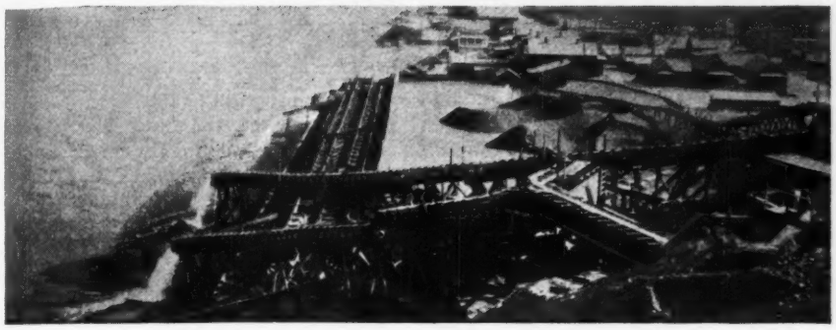


FIG. 1 FIG. 2 FIG. 4

FIG. 3

A ring, with a slight shrinkage, was carefully prepared from $\frac{3}{4}$x2$\frac{1}{4}$-in. mild steel. It was then heated and placed over the flange of the filter jacket, as shown in Fig. 2. Care was taken not to disturb the ring during the cooling period, and an air space was left at points *A* to effect a proper tightening of the flange end and closing of the crack without deforming the jacket bore accommodating the large stuffing-box flange. The crack was then sealed by drilling and filling the hole with a $\frac{1}{2}$-in. solid-copper pipe plug, followed by a series of overlapping $\frac{1}{4}$-in. copper plugs, as shown in Figs. 3 and 4. This operation may be greatly facilitated and better results are obtained by first drilling and plugging holes 1, 3, 5, etc., and then placing between them holes 2, 4, 6, etc., After completion the slightly protruding heads may be hammered down lightly to make the plugs perfectly leak-proof. This repair job was completed in less than five hours.

Lead Smelting and Zinc Fuming at Tadanac, B. C.



Lead slag is granulated and discharged by flumes

THIRD *of a series of articles on the technical operations of the Consolidated Mining & Smelting Company of Canada, Ltd.*

George J. Young
Associate Editor

TO UNDERSTAND the present position of the metallurgical practice at Tadanac, where the concentrates from Kimberley and custom ores handled by the Consolidated Mining & Smelting Company of Canada are reduced, one should review the metallurgy of the 1916 period. I will use as a basis for this the data given in an article by Dr. T. A. Rickard at that time.

Sullivan ores were selectively mined. As may be inferred, the two products, a zinc ore and a lead ore, were each handicapped by a large content of the adverse metal as well as by iron in the form of pyrrhotite and pyrite. The zinc ore contained, in percentages: zinc, 25; lead, 11; with the remainder principally iron in the sulphide form. The lead ore contained 14 per cent lead and 12 of zinc, with the rest also principally iron as sulphide. Silver in the zinc ore amounted to 3½ oz. per ton, and in the lead to 4 oz. Each ore was separately roasted. The roasted zinc ore was leached with sulphuric acid and the residue (about 87 per cent of the material, subjected to acid treatment) was sent to the lead-smelting department. Extraction of zinc was about 65 per cent, leaving about 35 per cent to cause trouble in the lead-smelting department. The dissolved zinc was recovered electrolytically. After sintering, the lead ore, together with custom ores and fluxes, was smelted in lead blast furnaces and the accessory zinc and iron were eliminated in the slags. The lead bullion was electrolytically refined by the Betts process.

I have indicated only the important steps. The combined hydrometallurgical and smelting process evidently resulted in only an incomplete saving of the zinc, though the lead recovery was comparatively high. Volume of products to be smelted was only diminished by the elimination of part of the sulphur in roasting, and the removal of about 65 per cent of the zinc. About three-quarters of the lead and zinc ores had to be passed through the lead blast furnaces.

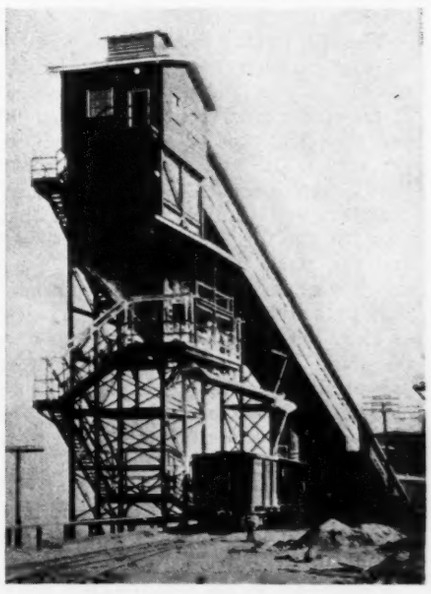
The greatest improvement in metallurgical practice began with the selective flotation of the mine ore, part of which, rich lead ore, was first picked out by hand, and the remainder sent to the concentrating plant at Kimberley. Selective flotation, which eliminated a large part of the iron sulphide, gave a zinc concentrate plus some lead, and a lead concentrate plus some zinc. Some lead and zinc were lost in the tailing. The economic results were important—only about one-third of the mine product was shipped to Tadanac and the lead and zinc concentrates were of a nature to gladden the hearts of the metallurgists concerned with their treatment. Selective flotation has been consistently improved since 1924. Flotation recoveries, considering the intimate association of the sulphides, are high—almost 95 per cent of the lead and about 90 per cent of the zinc.

The zinc plant at Tadanac now receives a zinc concentrate containing about 50 per cent zinc, with somewhat over 3 per cent lead, and the lead smelter, a product containing 70 per cent lead with less than 5 per cent zinc. Both of these, in the form of flotation concentrates, are in a finely divided condition. This physical state is of advantage in hydrometallurgical treatment by which the zinc is recovered, and the Dwight-Lloyd sintering furnaces successfully cope with the fine lead concentrate.

Zinc concentrate is roasted in Wedge furnaces, and the resulting material is treated with sulphuric acid as formerly. The residue, constituting somewhat less than 40 per cent of the weight of the concentrate, contains about 20 per cent of zinc, indicating about 82 per cent extraction. Thus, some 17 per cent of the zinc, contained in less than one-half the weight of material that was formerly thus treated, is sent to the lead smelter circuit.

The lead concentrate, mixed with zinc-plant residue, custom ores, and fluxes, is double roasted in Dwight-Lloyd roasters and the sinter smelted in lead blast furnaces, the zinc in the lead concentrate and in the zinc plant residue being eliminated principally in the slag, and partly in the dust and fume, which are retrieved in an elaborate system of flues and Cottrell treaters. The lead bullion is cast into anodes and sent to the lead refinery, as formerly.

During 1930 a slag-fuming furnace was added to the lead-smelting circuit, this significant feature resulting in greatly improved metallurgical results.



Zinc fumed from the lead furnace slag is elevated by belt conveyors and here discharged into railroad cars

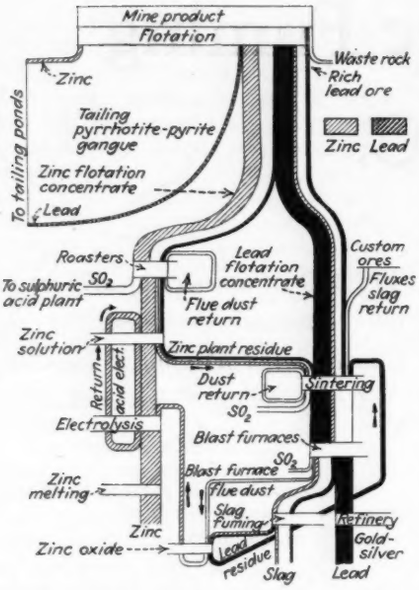


Fig. 1—Flow sheet, weighted according to tonnage, of lead and zinc concentrate treatment plants

The blast-furnace slag, bearing some 16 per cent of zinc and several per cent of lead, is treated in batches of 50 to 60 tons by blowing with air and coal dust, the combustion of which heats the slag and volatilizes the zinc and lead, which are oxidized in the excess air and are caught in a flue and baghouse system. Gases and suspensions are cooled by boilers and economizers before they enter the baghouse. The fuming treatment results in the recovery of 85 per cent of the zinc and almost all the lead. The mixed oxides are treated with sulphuric acid, the zinc is dissolved, and the residues containing lead are separated by filtration, the lead residue being returned to the smelter circuit. After purification the zinc solution is sent to the electrolytic department, where the zinc is deposited.

The slag fuming furnace partly closes an exit through which a considerable amount of zinc and some lead escaped. It raises the zinc recovery to about 90 per cent, and that of lead to about 95 per cent. The exit via the stacks has been supplemented by dust settling chambers and Cottrell treaters, so that most of the suspensions are retrieved and the stack losses are small. Slag loss in zinc is restricted by an economic limit to the time period of fuming a batch of slag, but there is little lead loss in the slag. The smelter circuit as thus improved represents a great advance in metallurgical practice. Furthermore, as far as the Tadanac plant is concerned, selective flotation has resulted in greatly reducing the actual weight of material to be smelted. In Fig. 1 the important steps in the metallurgical scheme are presented.

Summation of the metallurgical story would not be complete without reference to the sulphur dioxide problem. Gases from the lead blast furnaces and the sintering furnaces are so dilute that it is impracticable to do more than is being done with them—to remove fume and dust suspensions. On the other hand, the gases from zinc roasting contain higher and more controllable amounts of sulphur dioxide. Roasting practice is being studied, and a new method of roasting is being experimented with. The objective is a more thorough roast and a gaseous product containing about 8 per cent of sulphur dioxide. This product will be handled in sulphuric acid plants now under construction. In addition to the utilization of this gas, other byproducts are produced — cadmium, bismuth, and antimony. A small amount of tin occurs in the Sullivan ore, but this is not recovered at present.

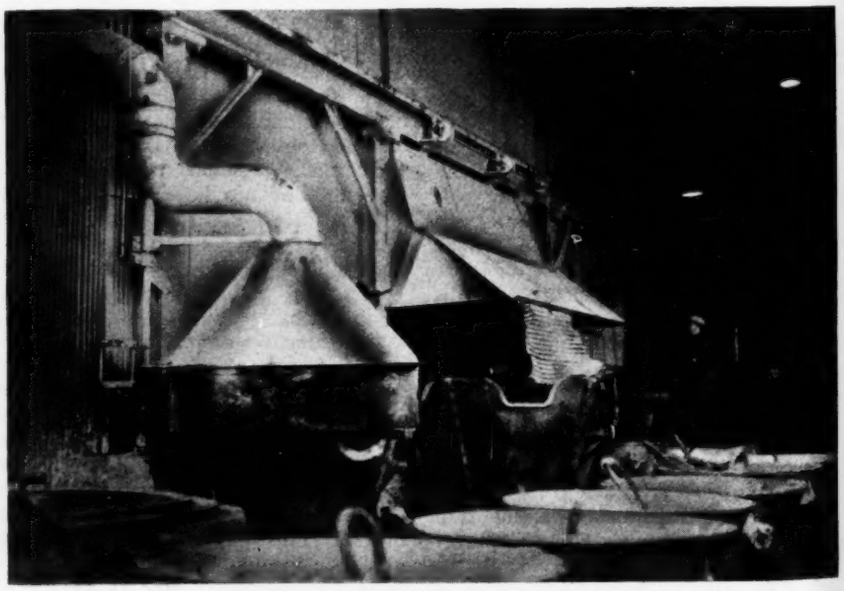
The metallurgical plant is divided into two major parts, one of which includes the blast furnaces, slag fuming furnace, anode casting department, sintering furnaces, crushing and mixing department, lead refinery, cathode sheet preparation, gold and silver refinery, copper refinery, receiving bins, and the system of flues, dust chambers, and Cottrell treaters involved in the smelting of the ores and lead concentrates. This part of the plant is almost wholly self-contained, but it receives the zinc-plant residues and delivers the zinc-oxide product of the slag fuming furnace to the zinc plant, receiving in turn the oxide-plant residues. A custom concentrator and crushing plant are also included in this unit.

The second principal part effects the treatment of zinc concentrates and zinc-oxide products. Wedge roasters, dissolving, thickening and filtering departments, three electrolytic houses, the oxide-dissolving department, the cadmium department and the melting and casting department are the major divisions of this unit. Included are the flue, stack, and Cottrell treaters of the zinc concentrate roasters and a hydrofluoric acid department. Separated from it is the contact sulphuric acid plant now in operation and the three new units under erection.

Transportation is effected by main-line railroad, and each major division is equipped with narrow-gage tracks upon which trolley-electric locomotives and trains are operated.

Lead Smelting Unit

The most significant feature of the preparation of the lead blast-furnace charge is the making of sinter upon a "quality basis," as Mr. G. E. Murray, assistant smelter superintendent, expressed it. As will be appreciated, a rich lead concentrate, containing only relatively small amounts of zinc and iron, is available, and a zinc plant residue that is high in zinc and contains lead. All is thoroughly mixed. Mr. Murray said: "We mix all of the material going to the first sintering twice and would do it three times if we had room. It is subjected to 28 turns, 14 on each table." This thorough mixing is a feature of the sintering practice. Dwight-Lloyd equipment consists of six machines each 264x42 in., and eight machines each 600x42 in. Six of the long machines are used on primary sintering, and two of the long machines and six short ones on the secondary sinter. The primary sinter is crushed by a special crusher developed at Tadanac. The sinter is only coarsely crushed, every effort being made to keep the charge porous. Bed thickness is 6½ in. on primaries and 12 in. on secondaries. The sinter contains up to 58 per cent lead. Sulphur is reduced from a low limit of 11 to 2 to 2.5 per cent. Ignition is accomplished by burners using Diesel



Hoods carry away the fumes arising from tapping. The conical hood is over a steel pot receiving the discharge from the siphon tap of the new lead blast furnace. To the right is seen the pot receiving hot slag for transferral to the zinc fuming furnace.

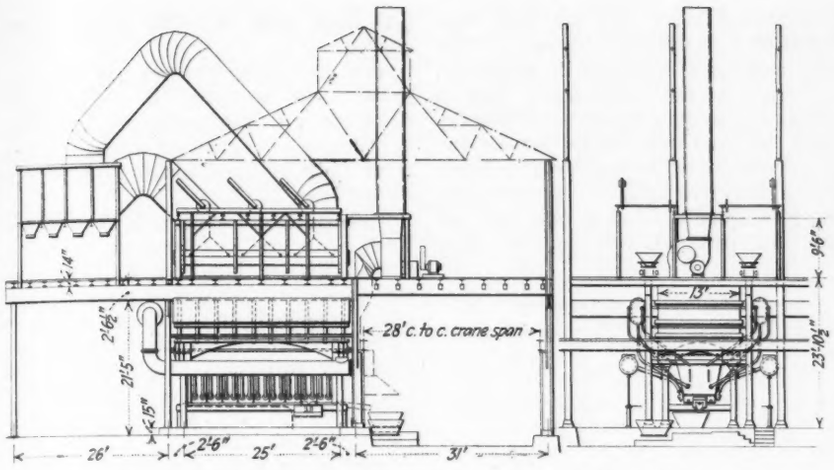


Fig. 2—General arrangement of new No. 12 lead blast furnace

oil operating in a small furnace superimposed above the bed a short distance in front of the feed position. This furnace is hemispherical in section. It consumes 0.2 gal. fuel oil per ton of material sintered.

The lead blast-furnace equipment consists of four furnaces each 45x180 in.; and a new furnace, 45x270 in. Three furnaces are in operation. The new blast furnace, No. 12, is 7½ ft. longer than the old-type furnaces, and smelts 50 per cent more charge. It is operated on a 32-oz. blast, but when driving the furnace a 42-oz. blast is used. Tuyères are eighteen on a side, two to each water-jacket section. The usual lead well or crucible is restricted to a short distance back of the tapping jacket, which is at the end of the furnace. An overflow lead tap is opposite the second jacket from the tapping end. Lead is laundered to a ladle placed close to the slag ladles in the slag aisle. Steel beams and side charging doors are water-jacketed. Charging doors are counterweighted. Jacket water is reduced to small amounts by the use of an economizer which permits thermal circulation, only the water evaporated having to be replaced. The tapping jacket requires the principal water used by the furnace. Although the ideas involved in reducing the amount of the cooling water were developed at Tadanac, it was later found that they had also been applied several years before in Colorado. The major details of the furnace are shown in Fig. 2. Mr. Buchanan, superintendent, is enthusiastic about the performance of No. 12 furnace.

Normally, the sinter produced in two shifts per day is 1,300 tons. Zinc-plant residues form 11½ to 15 per cent of the charge. Coke (83 per cent fixed carbon) is 10 per cent of the blast-furnace charge; slag fall is 35 per cent, with 55 per cent sinter; lead on the charge is 48 per cent. Slag runs 16 to 18 per cent zinc; 18 to 22 per cent silica; 29 to 30 per cent iron, and 9 to 11 per cent lime. The zinc-to-iron ratio in the slag is maintained at 1 to 1.8. No matte is made, the sulphur in the charge being too low. Furnace capacity is about 800 tons of lead bullion per day; for all furnaces the charges weigh 2,550 lb. and total 300 to 350 tons per furnace-day for the small furnaces. From this an average of 10 to 15 tons of fines and flue dust per day results. At present 1,300 tons of charge is producing about 500 tons of bullion per day.

No. 12 furnace, in conjunction with the slag-fuming furnace, has opened up new possibilities in furnace practice. The thorough preparation of the sinter reduces furnace accretions to a minimum, as the zinc is taken up by the slag and little is volatilized. By increasing the lead in the slag from 2 per cent, its normal, up to 4 per cent, the coke has been cut from 11 to 10 per cent, and is expected to be cut to 9½ per cent. Under these conditions the furnace operates freely, and no trouble is experienced at the lead well or at the tuyères. Its capacity in tons of charge is increased about 20 per cent. Evidently, an improved smelting practice is in the making. Mr. Murray showed me the results of investigations of tuyère zone conditions, and further improvements in the design of the lead blast furnace, particularly in the narrowing of the tuyère zone, would seem feasible. The increased lead content of the slag is not objectionable, because the lead is wholly recovered in the slag-fuming furnace.

Experiments were conducted at Tadanac for a long time on methods of slag treatment in which electrothermic heating was applied, and a successful method was evolved. At the same time, Anaconda experimented with slag treatment and also evolved a system, which was applied upon a working scale at the East Helena smelter. Coal-dust firing was found to be the most practicable method of heating the slag. Tadanac developed the slag-fuming system now in operation from its own research and from the experience gained at East Helena. The plant at Tadanac incorporates several improvements, the principal ones being a larger furnace and the utilization of the surplus heat generated in the process by means of waste-heat boilers and economizers.

The fuming furnace, completely water-jacketed on the sides, ends, and bottom, is covered with a firebrick arch in which are air-inlet openings. Two air inlets are also provided in the end jackets. The furnace is 10x20 ft. in section, the lower jackets being 6 ft. high; the upper jackets, in two tiers, are each 2 ft. high. A water-jacketed offtake flue leads to a brick flue, which connects with the waste-heat boilers. The furnace is equipped with 70 tuyères entering 7 in. off the bottom, to which air is delivered through 1½-in. pipe at a pressure of 6 lb. Five 1½-ton coal-dust tanks (one of which is a spare) on each side of the furnace receive their supply from a 45-ton bin above the small tanks. The small tanks are under 6-lb. pressure. At the bottom of each cone is a screw feeder which delivers into an ejector operating under 90-lb. air, and from this a 2-in. pipe leads to the header at the furnace, from which ¾-in. pipes lead to each tuyère.

In effect, the slag-fuming furnace is a combustion chamber. The slag is introduced in 50- and 60-ton batches through a hopper at one end, opposite the tapping end. At the tapping end are two 5-in. tap holes which discharge into a launder of V-shaped iron troughs. Discharged slag (50 tons in 20 min.) is granulated in a stream of water. The quiescent slag line would be about 2½ ft. above the tuyère line, but as the slag is violently agitated by the tuyère air it rises to a greater height. The tuyère air also forces the coal dust into the slag, so that reduction, volatilization of zinc and lead, and combustion of coal dust are simultaneous. Combustion also continues above the violently agitated slag charge and into the flue system. The proportion of coal is 25 per cent of the slag weight. Temperature of the slag is 2,250 deg. F. Above the slag level the combustion temperature is 2,350 deg. F. The reduced metals are quickly oxidized and carried out in the gaseous products of combustion.

Time is a factor in the elimination of the zinc from the slag. In the first half hour the zinc content is reduced from 16 to 8 per cent; in the second from 8 to 4 per cent; and in two hours to 2 per cent. The economic limit is placed at 3 per cent, so that about 85 per cent of the zinc is fumed, and under this condition all of the lead is also fumed. A turbo-blower with volume regulator supplies up to 15,000 cu.ft. of air per minute. Fuel and air are thus under constant conditions. A slag batch is introduced, treated and withdrawn, to be followed by another.

Following is a record of the approximate quantities as figured upon one-hour operation, with a 50-ton charge: air, 900,000 cu.ft.; lead fume, 2,500 lb.; zinc oxide (85 per cent zinc elimination), 9,500 lb.; total fume, 12,000 lb.;

weight of fume per minute, 200 lb.; total coal, 5 tons, or 166 lb. per minute. The slag fall is 80 per cent, and the cleaned slag contains in percentages: silica, 28; iron, 36; and lime, 12. Part of the granulated slag is returned to be used as a basic flux. The slag pots by which the fuming furnace is charged contain 9 tons of slag; but, as 25 per cent is shell, only 6 to 7 tons is charged into the furnace. This slag shell excess indicates the need for a slag furnace as a reservoir between the blast furnaces and the fuming furnace. As slag-fuming practice is in its development stages, one may expect that present details will be greatly improved. Stored granulated slag can be worked at present by feeding it into the fuming furnace as the slag pots are poured or while the charge is being worked.

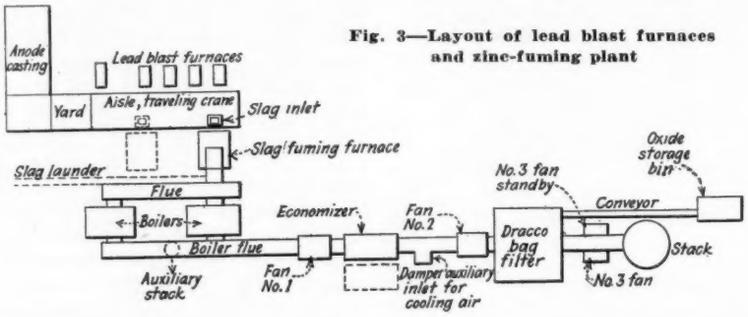


Fig. 3—Layout of lead blast furnaces and zinc-fuming plant

The waste-heat boiler inlet is under a vacuum of 0.3 in (water gage), maintained by fans on the flue system. A 1,750-hp. B. & W. boiler receives the gases at 2,000 deg. F. and discharges them at 625 deg. F. or less, after which they pass through a Green economizer which reduces their temperature below 250 deg. F. One such boiler is provided for each of the two furnaces. On the boiler flues and the boilers is a system of gravity discharge hoppers which collect a part of the fume. Boilers are equipped with Diamond soot blowers, and, in addition, are cleaned with hand lances twice each 1¾ hours. The volume of cooled gases at the baghouse, and including leakages, under present operating conditions, is about 100,000 cu.ft. at 60 deg. F. One boiler, in operation at the time of my visit, was developing about 1,300 hp., with steam pressure at 180 lb. No special difficulties have developed in boiler operation and after smoothing out the initial troubles the slag-fuming furnace has continued to work smoothly. Little or no rodding is required at the tuyères, although some is done as a precaution. No tapping trouble is experienced.

The economizer usually receives gases at 400 to 500 deg. F., and cools them to 250 deg. These gases are delivered by a paddle-wheel type of fan which draws them from the boiler flues. Interposed between the fan and the boilers is an auxiliary stack which can be used in the event of the stoppage of the fan. The discharge flue from the economizer connects with a second fan, of duplex paddle-wheel type. An air inlet controlled by a damper can be used to provide additional cooling if necessary. The second fan discharges into a Dracco bag system, which automatically filters the fume from the gas stream and by a system of screw conveyors delivers it to a conveyor belt. This discharges into a bin placed so as to load railroad cars, for transportation to the oxide plant. The Dracco installation consists of six 10-compartment units, making a total of 1,080 bags. A third fan, of the Sirocco type, supplemented by a standby fan, takes the gases from the Draccos (under 4½-in. draft) and discharges into a stack. All connecting flues are hopper-bottomed and are arranged for gravity discharge of fume. The system requires close control of temperatures. Gases entering the woolen bags must not exceed 225 deg. F. (an upper limit of 200 deg. is set) nor must they fall below the dew point. The outlet temperature is 90 deg. F. The economizer gives greater control of the lower temperature limit, as boiler water can be circulated through it and the gases heated up when necessary. A system of electrical control operates to close down all fans and open the auxiliary stack in the event of stoppage of any fan.

About half of the fume is caught in the Draccos and half in the flue system. Some selective action is apparent. The fume caught in the Draccos contains 71 per cent zinc and 5 per cent lead, whereas that from the economizer and flues contains 60 per cent zinc and 15 per cent lead. Provision has been made in the design of the plant, a sketch of which is shown in Fig. 3, for an additional slag-fuming furnace, another economizer and the doubling of the bag filter installation.

Methods for handling lead bullion have not greatly changed. The bullion runs continuously from the furnace and is caught in pots, which, when full, are moved by overhead cranes to the anode-casting department and poured into two 50-ton and one 100-ton reverberatory drossing furnaces through openings in the tops of the furnaces. The lead is laundered from these furnaces into three 60-ton and two 100-ton kettles, where it is drossed and then pumped to the anode casting machine. A dross retreatment furnace is part of the facilities. Lead anodes are handled on special cars, each of which holds a vat charge.

The lead refinery practice has recently been described in considerable detail by J. J. Fingland,[1] superintendent of refineries. From his paper I have taken only sufficient detail to serve for record here.

Tadanac lead refinery is the pioneer Betts plant and has been in operation since 1904, but has been enlarged several times. It contains at present 1,116 cells arranged in thirteen cascades. Cells are constructed of concrete protected by two coats of P. & B. paint (the first coat diluted with gasoline before priming) and a layer of asphalt (melting point 220 deg. F.). The submerged portion of the anodes weighs 364 lb. (total weight, 375 lb.) and anodes are spaced 4.125 in. center to center. Current density is 17 to 18 amperes per square foot, and the voltage drop between cells varies from 0.3 to 0.6 volts. Anodes contain 0.85 per cent antimony, or sufficient to give a slime sponge, which retains metal impurities present but does not interfere with the rate of lead deposition. Cathodes are thin sheets of lead (10 to 11 lb.), one end of each sheet being wrapped around a copper bar which makes the electrical contact.

The electrolyte consists of a solution of hydro-fluosilicic acid, lead fluoride, and lead fluosilicate, together with fluosilicates of impurities present, such as iron, antimony, and tin. Anodes are electrolyzed in eight days, and two crops of cathodes are taken in that period, the first crop containing from 0.06 to 0.12 oz. silver per ton; the second, 0.18 to 0.24 oz. Residual anode material, approximating 30 per cent of the original anode weight, is returned to kettles for remelting and casting into anodes. Cathodes are melted, heated to 1,000 deg. F., and treated with compressed air until the antimony is reduced to 0.001 per cent, which corresponds to complete elimination of tin and arsenic. Ten kettles, each of 60 tons' capacity, are used for cathode melting, and four kettles for remelting anode scrap. Two casting wheels are available for pig-lead casting. Two brands of commercial lead are made, one a low silver (0.08 to 0.12 oz. silver per ton) and the other ordinary pig lead.

Anode mud or slime that collects in the bottom of the electrolytic cells amounts to 2¼ per cent of the anode weight. Spent anodes are cleaned by sprays and revolving brushes. The anode slime is washed on vacuum filters for the recovery of electrolyte, and is then sent to the slime treatment plant. Electrolyte is handled by copper plunger pumps and copper centrifugal pumps, the wearing parts being of Monel metal. The maximum capacity of the refinery is 470 tons per 24 hours and when I

[1]The Betts Electrolytic Refining Process in Practice. American Electrochemical Society, June 1, 1930.

was there it was operating at about 400 tons per day. One section of the refinery is being operated on the basis of a six-day anode and three-day cathode.

About nine tons of anode slime is made per day, and this is received at the gold and silver refinery with a moisture content of 65 to 75 per cent. It is dried partly by waste furnace gases and charged into cylindrical tilting furnaces, where drying is completed and oxidation and melting follow. The slime contains arsenic, antimony, lead, copper, bismuth, gold and silver. Preliminary melting is in a reducing atmosphere. A maximum metal fall and a minimum proportion of lead antimonite slag are the objectives. The slag is desilverized by the addition of coal and coke breeze sufficient to give a metal fall of 10 per cent, which is returned to the tilting furnaces with the next charge of slime.

The first metal is subjected to a surface air blast treatment, and arsenic and antimony are eliminated as a fume, which is collected in settling chambers followed by a Cottrell treater. Fume contact, in percentage, is as follows: Antimony, 60; arsenic, 6 to 10; lead, 1 to 3; and silver, 2 to 20 oz. per ton. The residual 7 per cent of antimony remains in the metal and is removed by slagging under oxidizing conditions as lead antimonite. After the lead has been exhausted, copper and bismuth begin to oxidize, and their oxides are skimmed off. Copper oxide slags contain about 80 per cent of the bismuth present in the charge, the remainder being contained in the litharge slag. The antimony fume is reduced to metallic antimony, and the copper oxide and litharge slags are re-treated for the production of a lead-bismuth alloy, from which the bismuth is separated electrolytically. The first oxidation is carried out in a small reverberatory and the second in the doré furnace. The doré bullion is parted in iron kettles with 66 Bé. sulphuric acid. Final products of the anode slime are antimony, bismuth, silver, gold, and antimony-lead slag, which is returned to the smelter.

Tadanac has facilities also for handling copper concentrates and producing refined copper. These comprise a blast-furnace plant, a 60x18-ft. copper reverberatory with powdered coal firing by the Hardinge unit system; two 12-ft. Great Falls type converters; an anode casting wheel; and a 60-ton electrolytic refinery; with a 50-ton melting furnace, with casting wheel for producing ingots, wirebars and cakes. Cell equipment consists of 426 lead-lined wooden vats, this part of the plant working in series with the lead refinery. Refinery practice is along established lines.

Novel Elevator Installation

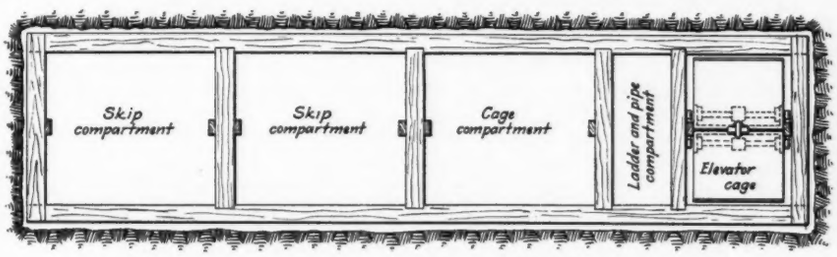


Fig. 1—Shaft arrangement, showing elevator cage in manway

OF THE numerous mechanical contrivances in use at the Pilares mine of the Moctezuma Copper Company, Pilares, Sonora, Mexico, that have materially helped to reduce operating costs, one of the most interesting from an operating and safety standpoint is the small auxiliary elevator in the Guadalupe shaft. This elevator provides rapid means of conveying shift engineers, repair men, and spare parts from the 1,800 level to the pump station on the 2,200 level, and facilitates the inspection and repair of the pump discharge column, without interrupting hoisting operations.

Particularly unique are the general shaft arrangement, the elevator cage operating in the manway, and the locally built hoisting unit, shown in Figs. 1 and 2. Owing to the limited space available, the cage, of light construction, is small, but it is sufficiently large to accommodate two men. It contains the operating mechanisms, as well as the safety devices found on the standard industrial elevator.

The electrically driven hoisting unit consists of the following essential parts: A bed plate; a cable drum, made of 10-in. pipe, with welded-on grooved brake flanges, gear, and bearing pedestals; an oil pump coupled to the drum shaft; a worm-gear speed reducer and attached drive pinion; an oil-operated brake mechanism, shown in Fig. 3; and a 25-hp. motor. As an additional safety measure, a solenoid brake is provided on the motor and speed reducer shaft coupling. The maximum rope speed is about 100 ft. per minute.

To assure open brake bands when operating the cage at normal speed, or when at rest, Shaft "A" (see Fig. 2) contains an adjustable counterweight, suspended from a short lever, to press the oil cylinder pistons back to their normal position. Oil pressure generated by the oil pump, in closed circuit with the neutralizing header tank, raises the levers of the eccentrics attached to the brake-band ends by short mild-steel rods, and thus tightens the brakes automatically. In the event of a sudden power cut-off, operations are safeguarded by the immediate action of the solenoid brake.

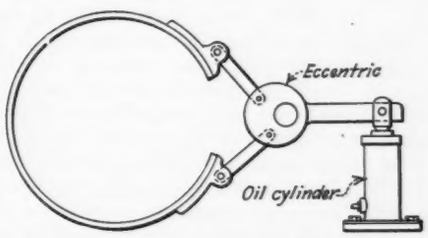


Fig. 3—Details of oil-operated brake-mechanism

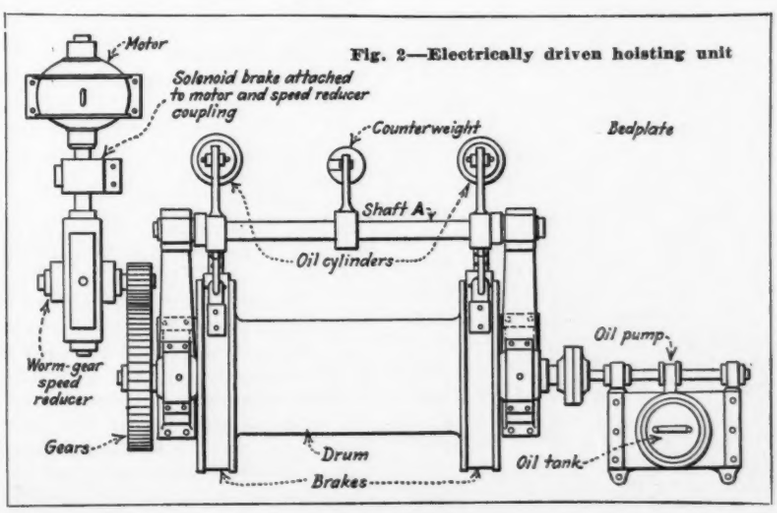


Fig. 2—Electrically driven hoisting unit

Advances in Zinc Metallurgy

A paper by R. S. Dean, chief metallurgist, U. S. Bureau of Mines—"Reduction of Zinc Ores With Methane"—aroused much discussion at the thirteenth annual meeting of the American Zinc Institute, held in St. Louis April 20-22. Mr. Dean's contribution to the proceedings, with brief abstracts of other papers read at the meeting, follows:

RECENT ADVANCES in physical metallurgy have imposed increasingly high standards on the purity of the zinc produced. From a condition where Prime Western zinc was the standard, and all higher grades commanded a premium, a condition has been reached where, in the mind of the buyer at least, electrolytic zinc of 99.99-plus purity is the standard, and all other grades are penalized. The prediction may confidently be made that trends in fabrication will cause this demand for high-purity zinc to increase. The operator in a district such as the Tri-State field is therefore facing a difficult future. He must either be content to sell to an indiscriminating market, or he must build an electrolytic plant. Even if he elect to take the latter alternative, he is at a disadvantage compared with his Western competitors, since he recovers no gold or silver.

With these facts in view, the U. S. Bureau of Mines undertook a critical study of zinc smelting to see what could be done to reduce the cost of the process and to produce a higher grade of zinc. Details of the study will be found in Bureau of Mines Bulletin 324, "Zinc Smelting From a Chemical and Thermodynamic Viewpoint," by Charles G. Maier, a study of which is recommended to everyone interested in the technology of zinc smelting. No attempt is made here to review the data given in the bulletin; the following merely indicates the conclusions and the subsequent developments.

The zinc smelting reaction $ZnO + C \leftrightarrows Zn + CO$ (1) may be written in two steps $ZnO + CO \rightleftarrows Zn + CO_2$ (2) $CO_2 + C \leftrightarrows 2CO$ (3); and the study indicates that the reaction actually takes place in these steps. As the second reaction is slower than the first, it restricts the speed of the total reaction. The solution of this difficulty is obviously to conduct the reactions separately, so that a larger chamber may be used for reaction (3). The gaseous reduction of ZnO with carbon monoxide or with water gas is, however, objectionable, because reaction (2) is reversed as the temperature is lowered, whereby much blue powder is formed. For this reason, to find a gaseous reaction for the reduction of zinc oxide, which would not be reversible with falling temperature, was obviously desirable. Such a reaction may be written

$$ZnO + CH_4 \rightarrow Zn + CO + 2H_2.$$

The methane could be provided from natural gas, a solution with attractive economic possibilities in view of the large amount of natural gas available in many zinc-producing regions at a low price. To work out such a reaction on paper is, however, only the first step. Conditions under which the reaction will take place must be discovered. Aided by thermodynamic studies, Maier was able to determine these conditions, which are: a temperature range of 850 to 1,000 deg. C., and the absence of appreciable amounts of iron or other catalysts that may cause decomposition of carbon monoxide in the condensing chamber.

A laboratory study of reduction by this process has been completed and is covered in Report of Investigations 3091, "Reduction of Zinc Oxide by Methane or Natural Gas," by H. A. Doerner. In this paper Mr. Doerner points out the following advantages of methane reduction:

1. *Cost as a Reagent.* Based on reducing power, as given by equation (1), 1,200 cu.ft. of methane produces one ton of zinc. In present practice about one ton of coal is required for this purpose. Methane, if completely utilized as a reagent, at 10c. per 1,000 cu.ft., is thus equivalent to coal at $1.20 per ton.

2. *Thermal Economies.* The most economical retort furnace requires about one ton of coal as fuel for each ton of zinc produced. In such a furnace, the endothermic heat of reduction is equal to about 11 per cent of the heat supplied,[1] and the use of the gaseous products of reduction for fuel is not feasible.

The combustion of the hydrogen and carbon monoxide resulting from reaction (1) will produce 2.76 times the endothermic requirements of that reaction; in the type of apparatus suitable for methane reduction, these gases may easily be utilized to heat the retorts. In a furnace having a thermal efficiency of 36.2 per cent, the exit gas from the retorts will maintain the temperature of reaction.

The following factors, peculiar to methane reduction, may make such a high efficiency possible: (a) *Low Operating Temperature.* The heat required to maintain a temperature of 900 to 1,000 deg. C. is very much less than that necessary for the present retorts at 1,200 to 1,400 deg. C. (b) *Thermal Conductivity of Retorts.* The thick clay retorts are poor heat conductors. At temperatures below 1,000 deg. C., a metal retort is a possibility. (c) *Thermal Conductivity of the Gases.* The gaseous products of methane reduction contain 50 per cent hydrogen, and equal parts of carbon monoxide and zinc vapor. Hydrogen is an excellent heat conductor. (d) *Continuous Countercurrent Operation.* Intermittent methods are thermally inefficient. Continuous and countercurrent operation is not only feasible, but practically essential, when methane is used for reduction. (e) *Radiation Losses.* The thin front walls of present furnaces radiate large quantities of heat. Retorts using gas for reduction can be inclosed in well-insulated furnaces.

3. *Maintenance.* Replacement of retorts and furnace linings is a big item in the cost of operation. At temperatures below 1,000 deg. C. the life of refractories is much greater, and the ore will not fuse and stick to the retorts, causing damage.

4. *Labor.* With a continuous, automatic feed and discharge of ore, and the use of gaseous fuel, labor is reduced to a small item and working conditions are very much better.

5. *Recovery.* (a) Low temperature, which eliminates fusion of the retort residues. (b) Continuous, countercurrent operation. (c) Low concentration of carbon dioxide in the gaseous products; all these conditions favor high recovery. With the use of carbon for reduction, the zinc vapor is expelled from the retort by the pressure of the gases evolved, which decreases as the reduction proceeds, so that the last portions of zinc cannot be profitably extracted. Using gas for reduction, the spent ore is subjected to continuous chemical and mechanical effect of a countercurrent flow of fresh gas, and complete utilization of the gas is assured by adequate contact with fresh ore.

[1] Liddell, Donald M. Handbook of Non-Ferrous Metallurgy, Vol. 2, p. 1209, McGraw-Hill Book Co., New York.

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6. *Quality of Product.* Zinc ores and the metal obtained by retorting usually contain lead. When reduced below 1,000 deg. C., very little lead will volatilize. Treatment of ores of much higher lead content than is now allowed may therefore be feasible. Formation of zinc oxide and blue powder in the condenser can be practically eliminated.

7. *Low Cost of Installation.* Most of the modern efficient zinc smelters use gas producers. With natural gas this expensive installation is not required.

The methane reduction therefore appears to have distinct commercial possibilities. To secure more data on the subject, a unit capable of producing 25-50 lb. of zinc per day has been built at the Rare and Precious Metals Experiment Station of the U. S. Bureau of Mines, at Reno, Nev., which is undergoing the pains incident to the transfer of operations from the laboratory to a larger scale. Next year I hope we may be able to describe this operation and point to the beginnings of commercial development.

The slag-treatment plant of Anaconda Copper Mining was discussed, at the recent meeting at St. Louis, in a paper by R. B. Caples, general superintendent, Great Falls Reduction Works. Complete description of this plant was published in *E.&M.J.* of Aug. 24, 1929. Briefly, the plant consists of a rectangular furnace, with sides, end, and top constructed of water jackets, and with bottom of water-cooled cast-iron plates on concrete foundation. Air and coal dust are admitted through tuyères along the sides; slag is introduced at one end, and gas and fume are taken off at the other end, cooled in steel pipes, and filtered through woolen bags. The fume collects in hoppers underneath the bags and is drawn into open-top cars for shipment to the elecetrolytic zinc plant at Great Falls.

A charge consists of 35 tons molten blast furnace slag. A furnace cycle includes about 30 min. for charging and 140 min. for blowing and discharging, or eight to nine charges per 24 hours. A two-hour blowing period gives a zinc elimination of 80 to 85 per cent. This may be increased to above 90 per cent by lengthening the blowing period. Coal consumption varies from 30 to 40 per cent of the weight of the slag, with 10,000 B.t.u. coal. Air consumption is about 8,000 cu.ft. free air per minute at 14 lb.

Lead comes off during the early blowing. Fume produced contains about 70 per cent zinc, with a zinc lead ratio of 12:1. Maximum production of any one month is 1,000 tons. This method of treatment has the advantage over methods previously tried, in that it permits the treatment of molten slag directly from the blast furnace, thus eliminating the cost of remelting the slag. Furthermore, cold slag may be treated more cheaply than in a blast furnace, as pulverized coal is used for heating, and the molten slag is treated in place for zinc recovery—that is, melting and reduction are conducted simultaneously in the same furnace.

The process has also found application at the Trail plant of Consolidated Mining & Smelting Company. In both plants a slag containing above 10 per cent zinc is treated, and the fume produced is handled in an electrolytic zinc plant.

Evans - Wallower electrolytic zinc plant at East St. Louis, described by Foster S. Naething, manager of the company, uses the Tainton process, following the general flow sheet of the Kellogg zinc plant, described in *E.&M.J.* of Dec. 1, 1928. It treats low-grade concentrates from the Joplin district, complex concentrates from Missouri and Tennessee, zinc silicate and carbonate, baghouse dust and Cottrell products, residues, scrap zinc, skimmings and dross, and concentrate from retort residues. Materials high in iron, cobalt, nickel, and germanium are treated successfully. Feed containing above 1 per cent sulphide sulphur and 0.2 per cent chlorine is roasted before treatment.

Previous to the roasting, the feed is reduced to 5 per cent moisture in two Lowden dryers. Three 25-ft. diameter, seven-hearth Wedge furnaces, fired with natural gas, are used. These are up-drafted on the upper five hearths, and down-drafted on the lower two. The up-drafted gas with 6 per cent sulphur dioxide is used for manufacture of sulphuric acid, and the down-drafted gas with 0.15 to 0.4 per cent sulphur dioxide is wasted. Each roaster handles 30 to 45 tons per 24 hours.

The calcine is leached in 25-ft. diameter lead-lined tanks with spent electrolyte, containing 26-29 per cent sulphuric acid, treating the magnetically separated ferrite portion first, and neutralizing with the oxide. The neutral pulp is filtered in four Burt filters, the residue from which is pumped to a 40-ft. settling tank, filtered on two American filters, and treated at a lead smelter, if the lead and silver content is sufficiently high. Filtrate from the Burts, with over 200 grams zinc per liter, is agitated with zinc dust. After complete precipitation of the impurities, the solution is filtered in Shriver presses, the filter cake is treated to recover copper and cadmium, and the solution is electrolyzed.

The cell room of the plant has 190 cells, each equipped with 12 aluminum cathodes and 24 perforated lead-silver anodes. A current density of 100 amp. per square foot is used. Cathodes are stripped every eight to twelve hours and charged to a rotary melting furnace, 6 ft. diameter and 10 ft. long, fired with natural gas and kept at a temperature of 500 deg. C. Casting is done from a 2,500-lb. ladle on a casting wheel. The metal produced averages better than 99.99 per cent zinc.

The Rosita smelter of Mexican Zinc Company, a subsidiary of American Smelting & Refining, was described in a paper by W. J. Jenni, superintendent, and R. F. Spooner, assistant superintendent. This plant treats concentrates from A. S. & R. mines in Mexico, and occasionally some custom concentrates. The concentrate mixture is dried in a Ruggles-Coles Type B-14 dryer, of 90 in. diameter and 50 ft. long. Four 20-ft., 12-hearth Skinner roasting furnaces are used, fired by coke-oven gas or slack coal. Each furnace pre-roasts 60 to 90 tons of concentrate per day, from 33 to 5-9 per cent sulphur. The pre-roasted material is sintered on a Dwight-Lloyd machine, with 63 in. wide pallets, and a wind box 60 in. long. Ignition is provided with coke-oven gas. Depth of charge averages 8 in. Sinter is crushed in a set of 24x48-in. Allis-Chalmers rolls followed by a 24x30-in. Jeffrey roll, and then mixed with fine coke in a Ransome concrete mixer.

The retort plant is comprised of eight blocks of retort furnaces, varying from 768 to 832 retorts per block. Cylindrical retorts, of 8¼ in. diameter and 60 in. long, are used. Two of the blocks are fired with coke-oven gas, and six with gas producers, of which five are of the R. D. Wood heavy-duty type, 10 ft. 6 in. diameter, and the sixth of which is the latest type made by the Morgan Construction Company, 10 ft. in diameter. Clay retorts are used on the producer-gas blocks, and they have an average life of 35 days. Carbide retorts used on the coke-oven gas blocks average 175 days. Condenser life is five to six days.

Metal is drawn three times during the day. Residue produced totals 40 per cent of the concentrate weight. The refinery consist of two 6x24-ft. reverberatory furnaces, 3½ ft. deep, producing Prime Western metal. A part of the roaster gases is converted into 98½ per cent sulphuric acid in a contact plant, with Grillo-type converter and Monsanto contact mass, having a daily capacity of 25 tons.

Prof. H. R. Hanley, of the Missouri School of Mines, in his paper, "Status of Zinc Processes," pointed out the specific advantages of the different methods used and the various factors governing the selection of a suitable process, such as fuel and power cost, type of feed, recovery of byproducts, and quality of metal desired. Elmer Isern's paper, "Centralized Milling in the Tri-State District," is covered by his article in *E.&M.J.* of Jan. 26, 1931.

Use of zinc sulphide as pigment in exterior paint and development of zinc-dust-zinc-oxide paints was discussed in a paper by H. A. Nelson, chief, pigment research division, New Jersey Zinc Company. An extensive abstract of this paper appeared in *Metal and Mineral Markets of* May 7, 1931.

Automatic Underground Pumping

Efficient and flexible system adopted at Burra Burra mine of the Tennessee Copper Company, comprising three operating centrifugal units, handles daily flow of 220,000 gal. in five hours

Lamar Weaver

SELECTION of the most effective pumping equipment available for mine drainage is an interesting problem. The exchange of information between operators and the eagerness of the manufacturers of pumping equipment to make improvements have caused rapid progress. Drawing on our own experience and that of others, we selected, for pumping at the Burra Burra mine of the Tennessee Copper Company, Ducktown, Tenn., the semi-automatic electric control of stage pumping, the stage lift for reduced head and pipe pressure effecting a reduction

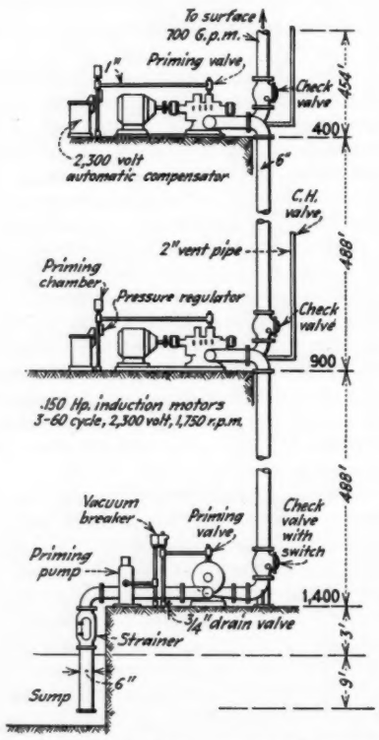


Fig. 1—General arrangement of pumping and control equipment

in the first cost of equipment, more economical repairing, and an increase in efficiency. Although the subject of controlling pumps automatically is a familiar one to many, the particular combination decided upon in this instance is probably varied enough to be interesting.

The pump duty for which this equipment was selected is as follows:

1. Vertical lift in feet, 1,440.
2. Quantity of water per 24 hours, 220,000 gal.
3. Acidity of water—parts per million, 120.
4. Solid content of water, 0.57 oz. per cubic foot.

The pumping equipment in use (including a spare unit) when a change was first considered consisted of three four-stage 4-in. centrifugal pumps with a rated capacity of 400 g.p.m. and 55 per cent efficiency, both casing and elements being made of acid-resisting metal; three 150-hp., 1,750 r.p.m., 2,300-volt induction motors; and a 6-in. cast-iron discharge column.

A pump on the 1,400 level raised the water to a sump on the 700 level. A second pump on this level pumped the water to the surface. Storage capacity was 180,000 gal. on the fourteenth level and 50,000 gal. on the seventh level. Each pump required an attendant for two-shift operation during the last eighteen months.

To provide ample protection for possible delays and arrangement of pumping hours for minimum power demand, the storage capacity was increased to 30 hours' storage, or 275,000 gal. In increasing the capacity of the 1,400-ft. level sump, those in charge of operations decided to drive an incline from the level station and to drift about 120 ft. to within 10 ft. of the old sump, and then to excavate for the desired capacity before connecting sumps. Of this drift (7x8 ft.) a 70-ft. section is used for settling solids in the mine water by use of suitable dams and baffles before it enters the sump.

Fig. 1 shows the general arrangement of the pumping and control equipment. The two-stage, balanced-unit centrifugal pumps, driven by 150-hp., 2,300-volt motors, are connected in a series of three lifts, from 1,400-ft. to 900-ft. level, thence to the 400 level, and thence to surface. The new equipment includes three 700-g.p.m. centrifugal pumps, one spare motor and pump, with the necessary starting and control equipment, consisting of a strainer, priming pump, priming valve, vacuum breaker, and hand compensator for the lower pump. Starting equipment for the pumps on the ninth and fourth levels includes a priming valve, a priming chamber, and an automatic starter. The mechanical protection for each pump is the pressure

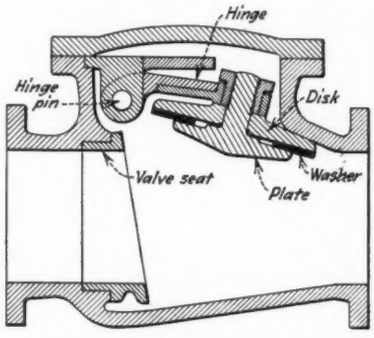


Fig. 3—Sectional drawing of check valve

regulator and flow switch with load relays for the ninth and fourth compensators.

The various protective features with their respective duties are:

1. The check-valve flow switch, which acts as a safety device, shutting down the motor in case the pump fails to deliver water for any reason. This switch is connected to the hinge of a

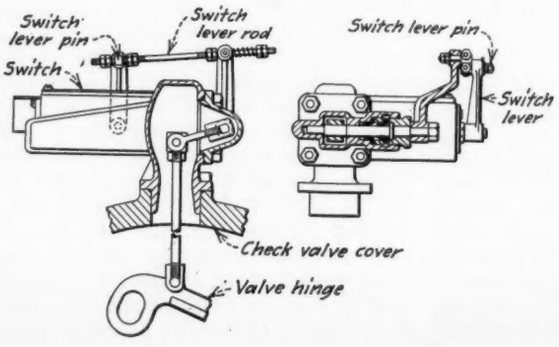


Fig. 2 — Sectional drawing of check valve flow switch

Hazleton check valve, as illustrated in Fig. 2. When the valve opens, the hinge rises and closes the switch. When the flow through the valve stops, the hinge drops and opens the switch. Fig. 3 shows the valve itself in cross-section.

2. Pressure regulator relay, which serves to stop the motor if the discharge line breaks or the check valve sticks.

3. Load relay, the function of which is to stop the upper pumps if the lower pump fails, or to prevent the starting of the upper level pumps until the lower pump has been started.

4. Gage board, including the ammeter, pressure, and vacuum gages, for determining the performance and conditions of units.

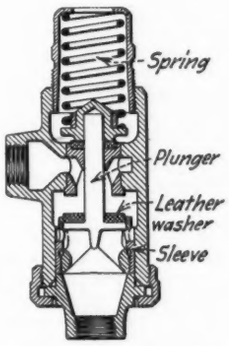


Fig. 4 — Sectional drawing of vertical spring - operated priming valve, with female socket (below)

The pumps are of the No. 4 EV type furnished by the A. S. Cameron Steam Pump Works. They are of all-bronze construction and have stainless-steel rings, steel shafting, double-suction bronze impellers, and Kingsbury thrust bearings. The automatic starters, of the inclosed oil-immersed type, were furnished by the Electric Controller & Manufacturing Company, and the various control equipment by Barrett, Haentjens & Company.

The pump on the 1,400 level is primed by a vacuum pump. This priming pump exhausts the air from the centrifugal casing, causing the water to rise from the sump below the pump level through the 6-in. open suction and the pump casing, out the priming valve (Fig. 4), and into the vacuum breaker. This breaker contains a float and switch. When the chamber fills with water the float closes the switch, turning on an electric light indicating to the attendant that the pump is primed. The centrifugal pump motor is then started with a manual compensator and the priming pump stopped.

As the pump starts, the flow of water opens the 6-in. check valve, closing the check-valve flow switch. The pressure building up in the pump casing closes the pressure-regulator contact and establishes the holding circuit for the hand compensator.

The water goes up the 6-in. discharge pipe to the suction of the 900 level pump, through the pump casing and out the priming valve (Fig. 4) and into the priming chamber (Fig. 5). Any air that may be in the circuit is given outlet through the 2-in. vent pipe and the priming valve. [The plunger of this valve carries a leather washer held in place with a sleeve which prevents the washer from sticking to the valve seat. During the priming operation, air is drawn through a number of small holes in the sleeve. These holes offer little resistance to the air movement but retard the flow of water when the pump is started and attempts to discharge water through the valve. Thus a pressure is built up on the under side of the plunger and the valve is closed against the pressure of an adjustable spring].

In common with the vacuum breaker, the priming chamber has a float and switch. The switch contact closes a circuit for automatically starting the pump. Flow of water from the pump opens the check valve and closes the switch, and the pressure regulator contact is made for the circuit as described for the 1,400 level. The water pressure also closes the priming valve, permitting the water to drain from the priming chamber, which breaks the starting switch and clears for the holding circuit (check-valve flow switch and pressure regulator). Priming, starting, and operation of the 400-level pump is the same as in those operations of the 900-level pump.

The load relay circuit is independent of the holding circuit mentioned, and simply affords additional protection against running the upper pump after the 1,400-level pump is stopped. Each starter has an emergency or master hand switch for starting or running motors for test purposes.

Manual starting of the 1,400-level pump is employed for economy in purchase cost only, as it is desirable to have an inspector go over the equipment for the purpose of cleaning and lubricating it, and to remove solids from the settlers and in general be responsible for the pumping. This application, though one of semi-automatic control, incorporates all the features of proved automatic control equipment. The pumping system as described was installed Aug. 1, 1930. Adjustments were effected during the first two weeks of operation, and since that time one man has handled the plant, as proposed in the original estimate, with excellent performance.

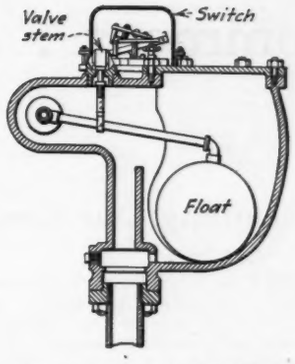


Fig. 5—Sectional drawing of priming chamber with switch

The important features of the system here described are:

1. It handles the daily flow of the mine in slightly less than five hours.

2. It provides water storage for 30 hours.

3. A complete spare unit is provided for emergency.

4. Power efficiency of 67 per cent is obtained.

5. Maximum pressure on the discharge column is 530 ft.

6. The system may be maintained and operated by one man.

7. The pumping system is one that can be added to as the mine acquires greater depth with small additional investment.

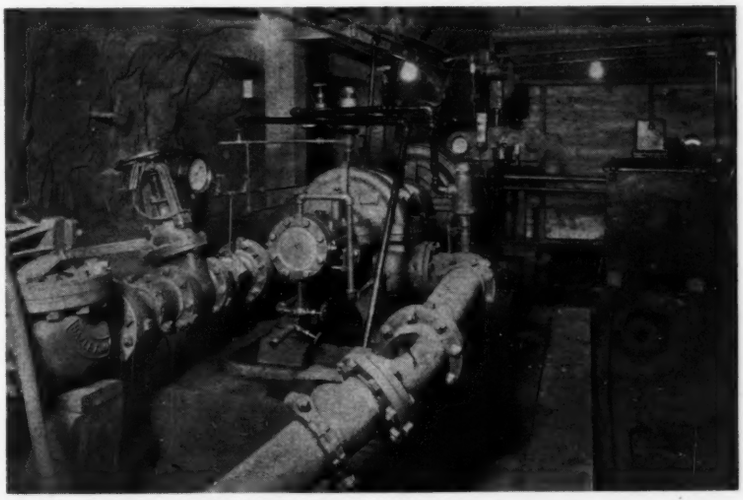


Fig. 6—New pump installed on fourth level of Burra Burra mine

Comment . . . Criticism . . . Personal Notes

Among Our Contributors:

DWIGHT L. SAWYER, a graduate of Stanford University, has had a varied and successful career in mining exploration work, and as geologist or mining engineer in Colorado, Arizona, British Columbia, and Cuba, on the technical staffs of Ray Consolidated, American Metal, Granby Consolidated, and other companies. During the War he saw active service as a captain of engineers.

ERNEST A. HERSAM, an alumnus of the Massachusetts Institute of Technology, professor of metallurgy at the College of Mining, University of California, Berkeley, is well known as an educator; for his contributions to contemporary technical literature; and as a contributor to current thought on ore dressing and ore treatment.

JOHN S. DEAN is renewal-parts engineer at the Homewood, Pa., plant of the Westinghouse Electric & Manufacturing Company.

MORRIS J. ELSING, a consulting engineer with headquarters at Tucson, Ariz., contributes in this issue the fifth of a series of articles on mining methods. The final article of the series, to be published shortly, will discuss caving practice.

LAMAR WEAVER, associated with the Tennessee Copper Company for many years, is assistant superintendent of its mines, including the Burra Burra, in which is installed the system of automatic centrifugal pumping of which he now writes.

L. G. KHVOSTOVSKY was graduated from the Polytechnic Institute of Kiev in 1914, obtaining field experience in Baku and Turkestan. He is now the representative in the United States of the United Chemical Industries of the U.S.S.R., and he also holds the post of vice-president of the Amtorg Trading Corporation and director of its Chemical Export Department.

■ ■ ■

Bela Low announces the removal of his office to 24 Broad St., New York.

Letson Balliet, of Tonopah, is chairman of the Governor's emergency committee on employment of the State of Nevada.

C. H. Adamson, secretary of the Stephens-Adamson company, is now in charge of the Chicago office, with headquarters in the Civic Opera Building.

Col. A. L. Bishop was elected president of Coniagas Mines at the recent annual meeting of the company. He fills the vacancy created by the death of Col. R. W. Leonard.

M. W. von Bernewitz, for ten years at the Pittsburgh Experiment Station of the United States Bureau of Mines, has been transferred to the Health and Safety Branch, Washington, D. C.

R. B. Caples, general superintendent of the Great Falls reduction department of Anaconda Copper Mining, delivered a talk before the Montana Society of Engineers at Butte recently. His subject was ore and concentrate purchasing.

C. H. Nonamaker has been elected secretary and treasurer of Tonopah Mining, filling the vacancies created by the recent death of P. S. Bickmore. **Miss Jean Hacker** was made assistant secretary and assistant treasurer.

Tomás Barrera has been awarded a Guggenheim fellowship, and will work at Harvard University. The personal item published in our April 13 issue was erroneous in the name presented and in the designation of the university concerned.

Bradley Stoughton, for several years secretary of the A.I.M.E., and since 1923 professor in charge of the department of metallurgical engineering at Lehigh University, has been appointed metallurgical consultant to the Baldwin Locomotive Works.

Walter A. RuKeyser, appointed last year as consultant to the U.S.S.R. state trust "Uralasbest," is contributing to *The Nation* a series of six articles on Russian industry, including two entitled: "The American Engineer at Work," and "The Outside Life of the American Engineer."

John F. Harman, chairman of the board of directors of Handy & Harman, dealers in silver, announced his retirement on May 1. On this date he celebrated his 87th birthday and his 64th year with the company. **Joel L. Brush,** treasurer, with the company since 1900, also retired at the same time.

Otto C. Davidson, superintendent for Oliver Iron Mining on the Menominee and Gogebic ranges for the last 30 years, retired on May 1. Mr. Davidson has been prominent in the development of the mineral resources of upper Michigan. George J. Eisele, assistant superintendent on the Menominee range, will assume Mr. Davidson's duties, although his title for the present will remain unchanged.

Sydney H. Ball and **Stanislaus Skowronski** will represent the A.I.M.E. on the recently formed Engineering Societies Monographs Committee. This committee will have editorial supervision over a series of technical treatises to be known as Engineering Societies Monographs. These will comprise technical manuscripts which have not heretofore been available to the profession because of too great a length for inclusion in technical journals and of too specialized a character to justify ordinary commercial publication in book form. The publishers of this series will be the Engineering Societies Library.

In Pursuit of the Ideal

To the Editor of "E.&M.J.":

Mining in this iron-ore country is getting to be one of the safe occupations. Keeping everlastingly at it, as you say in a recent editorial, has had splendid results.

For the last twelve months 1⅜ men were killed in mines here per thousand employed. This record is about as good as the country ever has made, for in 1905, when intensive safety work was initiated, the number killed was 7½ per thousand. From that time there has been a fairly steady and consistent improvement.

As many as 20,000 men have been employed in mining here, the number ranging down to as low as about 8,000, as now.

This decrease in fatalities has been due to attention paid to the safety of employees. Mine operators have fully equipped safety departments, with supervisors constantly on the job on surface and underground. They have spent vast sums in devices for insuring safety, and they are continually educating their men to the importance of the work. They have formulated elaborate sets of rules, and any shift boss or foreman permitting their violation is liable to instant dismissal.

So, from being a hazardous occupation —96 men were killed in 1905 and many more were injured—it has become so safe that only 13 were killed in 1930 and only 29 had lost-time injuries. But for the instruction given in first aid the number of fatalities resulting from these injuries would have been greater, no doubt.

The federal Bureau of Mines maintains a rescue car and conducts a consistent safety propaganda, by advice, instruction, and exhibits. Its co-operation has been of the utmost importance to the general safety campaign, and too much credit cannot be given it. The annual safety conventions, usually held in this city, serve to maintain close contact between the operators, the Bureau, and the miners, and to act as a clearing house for information gained by any of those interested.

I think it may be said without exaggeration or prejudice to other mining regions, that this district has led in safety work, has been a model to be followed, and that its influence has penetrated into almost every remote region where mining is an occupation. DWIGHT E. WOODBRIDGE.

Duluth, Minn.

Placer Gold in Peru

To the Editor of "E.&M.J.":

In the issue of March 23, 1931, appeared an article relative to the possibilities of gold placers upon the Inambari River in Peru. The basis of the hope that commercial placers might be discovered there seems to have been founded on the gossip and tradition that center around and emanate from little-known and far-off regions. Respecting the Inambari River region in question, these stories have attracted attention in the past and have been investigated by engineers who have sought specific information about the occurrence of placer gold, and have investigated the general conditions that would have to be considered were placers to be worked. At least three different parties went over the ground without finding suitable areas for commercial exploitation. The last expedition made an investigation for a California mining concern. The party of five Americans spent the summer of 1928 on the lower Inambari River. They entered upon the heels of the great earthquake of April 8, 1928, and found their progress impeded by the disturbances resulting from the earthquake. With excellent equipment and provisions for two years, the party finally reached the lower river and made investigations.

About 30 miles of the main Inambari were examined below the junction of the San Gaban branch. The river is a torrential stream some 200 to 300 ft. in width with a channel 400 or 500 ft. wide. Water flow is 10,000 sec.-ft. and up. The region is subjected to cloudbursts and heavy rains; the topography is broken and acute; and a tropical jungle makes exploration difficult and uncertain. A large flat area was found that indicated dredging possibilities. This was carefully examined. Bedrock exposures made it possible to get complete sections at a number of points, but only a few cents per cubic yard was found. Other gravel banks were tested by trenching and shaft sinking, but no interesting concentrations of gold were found. The general geological formation of slate with granitic intrusions and dikes is generally accepted as favorable for the occurrence of gold-bearing veins, but quartz was conspicuously absent, in the gravels and as veins. Operating conditions were considered to be generally unfavorable by reason of irregular bedrock and the boulder content of the gravels, as well as from results of the heavy floods, following the earthquake, which had filled up the channel and formed extensive log jams. In addition, the charges that might be imposed by the national and local governments in the form of royalties and special taxes and also the adverse transportation conditions were considered to be unfavorable factors.

The fact that dredges have been tried out on the river is not of importance as proof that the district is rich in gold. A flood destroyed the last dredge placed in operation after it had dug its way across the river from the construction pit. The yield is said to have been about $100.

Although the party was prepared to extend its examination over a wider area, the results of the summer work were considered to be sufficiently conclusive to show the impracticability of dredging, and to indicate that other methods of working presented no encouraging features. Gold was found, but never in sufficient quantity to encourage a detailed examination by drilling. There is a small production of gold from this region, probably not above $1,000 a year, made by parties of natives who go down from the high plateau between crop seasons to work the bars and bedrock exposed during low water. This can go on indefinitely, as more fine gold is deposited during high water by movement of the stream-bed gravels and caving in and concentration of the present banks, but the outlook for discovery and operation of large high-grade deposits is unfavorable.

MINING ENGINEER.

San Francisco, Calif.

Flotation Terminology

To the Editor of "E.&M.J.":

Your editorial, "Mineral vs. Gangue," in the March 23 issue, suggests the following considerations:

The most recent volume on flotation, "Milling Methods," and Professor Taggart's "Handbook of Ore Dressing," give the following terms for designating the relative conditions of a mineral with respect to the flotation process. They may be arranged in five divisions: (1) Normally floatable mineral, floatable mineral, readily floatable mineral, ordinarily floatable mineral; (2) non-floatable mineral; (3) particle to be floated; (4) unwanted mineral; (5) temporarily non-floatable mineral.

The four terms in Division 1, used more or less interchangeably, have substantially the same meaning. The variety of language employed is due to the fact that the "floatable mineral" is the one most frequently considered in writing on flotation. To avoid repetition of the same set phrase, writers are led to use different descriptive words with the unchanging "floatable mineral." The terms as used appear to have general significance, and no definite limits are set as to where one applies and another does not. They have not been defined, so far as I know.

To make this terminology more concise, a device frequently employed in language may be used: that of omitting a noun from a phrase and using the modifying word or words alone. Thus we speak of "the good," "the easily led," "the coarse." By this means, a characteristic word can be extracted, providing a term lying close to the phrase it supplants, both as to significance and familiarity.

Therefore, for any term in Division 1 could be substituted the term "floatable." A floatable would be a mineral having the same characteristics as a normally or readily floatable mineral, such as chalcopyrite, galena, or chalcocite. For "non-floatable mineral" can be substituted "non-floatable," —a mineral identical in properties with a non-floatable mineral. Such would be quartz and calcite. A "particle to be floated" could as readily be called a "to-float." A "to-float" might be galena, chalcopyrite, or chalcocite. "Unwanted mineral" could be replaced by "not-float"—mineral that it is desired not to float. A common example is pyrite. Finally, "temporarily non-floatable mineral" can be shortened to "tem-non-float." A "tem-non-float" is sphalerite.

To test the applicability of these terms, portions of the literature where this nomenclature is frequently employed have been extracted, and the suggested terms substituted wherever possible. Examples follow:

1. Processes in which the surfaces of the particles of one of the *normally floatable minerals* are permanently changed by chemical action so as to render the particles non-floatable.	1. Processes in which the surfaces of the particles of one of the *floatables* are permanently changed by chemical action so as to render the particles non-floatable.
2. These are not properly differential-flotation processes for the reason that before flotation is attempted, particles of an originally *floatable class* have been permanently changed into the *non-floatable class* by an irreversible chemical reaction and subsequent flotation differentiates only between *readily-floatable* and *non-floatable particles* rather than between two minerals of the *readily-floatable class.*	2. These are not properly differential-flotation processes for the reason that before flotation is attempted, particles originally *floatables*, have been permanently changed into *non-floatables* by an irreversible chemical reaction and subsequent flotation differentiates only between *floatables* and *non-floatables* rather than between two *floatables.*
3. Under this heading are included all those processes in which some substance, usually a salt, is added to a flotation pulp for the purpose of rendering one of the *ordinarily-floatable minerals, temporarily non-floatable.*	3. Under this heading are included all those processes in which some substance, usually a salt, is added to a flotation pulp for the purpose of changing a *floatable* to a *tem-non-float.*
4. These investigators then went on to formulate the further hypothesis that a collecting agent is effective when the compound it forms with the *particle to be floated* is less soluble than the unchanged surface of the same particle, and not otherwise.	4. These investigators then went on to formulate the further hypothesis that a collecting agent is effective when the compound it forms with the *to-float* is less soluble than the unchanged surface of the same particle and not otherwise.
5. In gaging the work done at the Sullivan Concentrator . . . R. W. Diamond has been using an index known as "metallurgical efficiency," which embodies the requirement of considering the rejection of *unwanted mineral* from the concentrate.	5. In gaging the work done at the Sullivan Concentrator . . . R. W. Diamond has been using an index known as "metallurgical efficiency," which embodies the requirement of considering the rejection of *not-float* from the concentrate.

New York City. FRANCIS TARTARON.

[We doubt whether "to-float," "not-float," and "tem-non-float" could ever be popularized. "Floatable" and "non-floatable," however, would seem easy to use and understand.—THE EDITOR.]

■

Obituary

John P. Boyle, of Salt Lake City, died in a hospital in that city on April 18, after a short illness. He was 64 years old.

William Womack died in Colorado Springs on April 20, at the age of 81. He was the last of his family, which owned the ranch that was developed as the Cripple Creek mining camp. The property which they sold for a small amount later produced $250,000,000 in gold.

Owen J. Byrnes, of Helena, Mont., died recently in a Chicago hospital. He was active in mining in the Marysville district of Montana. He was also active in politics, and served one term in the Montana State Senate and also one term in the House. Mr. Byrnes was 64 years old.

Philip O. Longyear, of San Jose, Calif., was killed near his home on April 25, in a glider accident. He graduated from the mining department of the University of California in 1923, and had been employed by Anglo-Chilean Nitrate and Miami Copper. Mr. Longyear was 35 years of age.

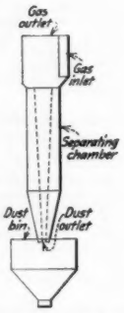
Leonard Cahoon, of Salt Lake City, died at his home on April 8. He was 49 years of age. Mr. Cahoon, who was Western representative for the Foster Wheeler Corporation at the time of his death, was formerly on the staffs of U. S. Smelting, Refining & Mining, Chief Consolidated Mining, and International Smelting. He was a past president of the Utah Society of Engineers and also of the Engineering Council of Utah.

INDUSTRIAL PROGRESS

New Mechanical Dust Collector Effective for Small Installations

Other New Equipment

A MECHANICAL dust collector, for which high efficiency is claimed, has recently been developed by the Western Precipitation Company, Los Angeles, Calif., for use where the Cottrell process cannot be applied because of combustile mixtures or the small size of installations. It is known as the "Multiclone" and is shown in an accompanying cut. Thus far, it has been applied principally in the chemical industries, but extension of its use to the mining industries is anticipated. In general, it is said to be applicable wherever finely divided materials are to be collected from air or gas.

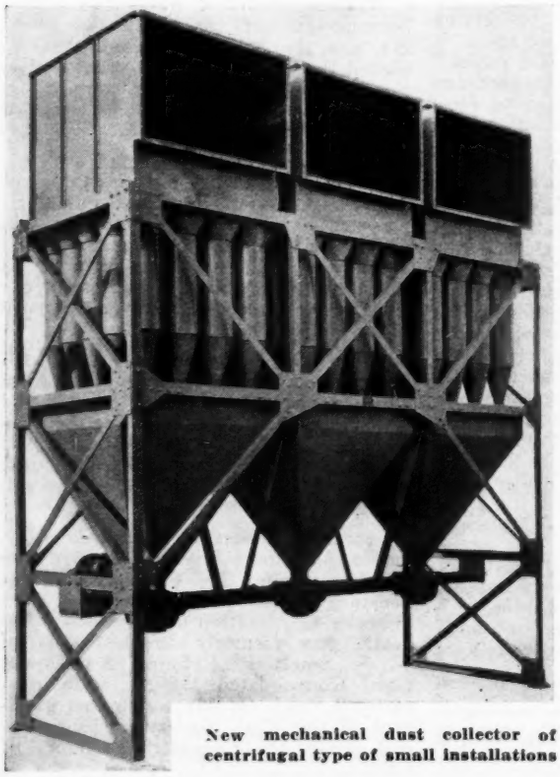


Single typical tube of new dust collector

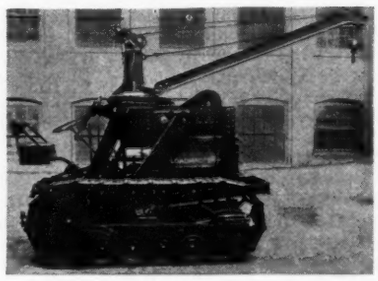
This dust collector is of the centrifugal type and represents the successful solution of the problem of working small centrifugal units in parallel. The small unit has an advantage over the large one, because the separating action of a centrifugal-type collector varies inversely as the radius and directly as the square of the tangential velocity of the gas. Thus, decreasing the diameter of the separating tube decreases the maximum travel of the dust particles and increases the centrifugal force available at a given velocity. A unit of small diameter, moreover, can be practically proportioned so that it operates at a high velocity with a low draft loss. To employ these advantages and at the same time be able to handle large volumes of gas, a large number of small units must be operated in parallel.

As the illustration shows, the new separator embodies a number of tubes of relatively small diameter, wherein high velocities are obtained with minimum power consumption. By these means, it is claimed, the theoretical limit of separating efficiency obtainable with centrifugal force can be approximated closely. The centrifugal forces set up within the tubes are many times more powerful than gravity, it is asserted. The accompanying sketch shows a single typical tube. Its cylindrical shell extends considerably below the outlet. The outer vortex containing the suspended particles is kept separate from the inner vortex traveling toward the gas outlet, owing to the high rotational stiffness of the gas stream in a small unit, and it reaches to the dust outlet. Pressure expended upon the unit causes the gas in the outer vortex to be forced radially inward, while the dust particles are forced outward by radial acceleration. In such a unit as that shown, a particle becomes separated from the gas stream and reaches the walls of the separating chamber on traveling only a short distance. Gravity plays a minor part in conveying it into the dust bin. After reaching this bin, the particle is allowed to settle out while the gas that carried it returns along the axis of the dust outlet back into the separating chamber.

Cyclone collection of dust has previously been limited to dusts in which the particles have been comparatively large. The new collector catches a higher percentage of dusts containing smaller particles. The minimum size which it will retain depends on the specific gravity of the material as well as on the size and shape of the particles.



New mechanical dust collector of centrifugal type of small installations



This crawler crane has a capacity of 3,500 lb.

Specific advantages of the new collector are: reduction of turbulence (a disturbing factor in cyclones of large diameter) to a minimum; maintenance and operating costs are negligible as compared to those of the bag-type collector or spray chamber; minimum floor space required; ease of handling and installing because of unit construction; ability to check or eliminate corrosion by using corrosion-resisting materials in contact with the gases; ease of cleaning because of sectional construction; ease of handling hot gases and removing collected material.

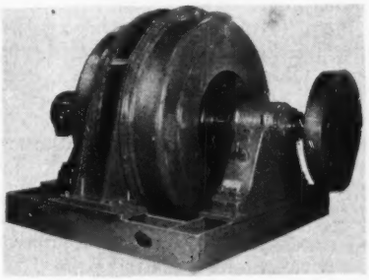
Crawler Crane Is Mobile and Easy to Operate

The caterpillar-mounted crane shown in the accompanying cut is known as the "Loadmaster," and in the future will be manufactured and sold by the Bucyrus Erie Company, South Milwaukee, Wis. It has a boom swing of 360 deg., a rated capacity of 3,500 lb., and a maximum working reach of 14 to 16 ft. It may be mounted either on crawlers, as shown, or on rubber-tired wheels, in the latter

case having a maximum traveling speed of about 11 miles an hour. It can be used either as a stationary, revolving boom crane, as a crane traveling with its load, or as a tractor. It is said to be very mobile and easy to handle.

New Motor Has Separable Parts

In the design of its new W-frame, Type CS, squirrel-cage induction motor, the Westinghouse company has incorporated an important innovation in making the different parts of the motor as entirely separate units. The company has only to keep the number of standardized parts in stock to be able to build a motor for a specific application on short notice. The new design is said to make maintenance simpler and less expensive because damaged electrical parts can be replaced without replacing or rewinding the motor. In the new motor the stator core containing its winding is pressed into the motor frame. If necessary to replace a damaged winding, the old core and winding may be pressed out of the unit by means of an arbor press and a new core pressed in. Then, after the motor is reassembled, it is ready for use. Likewise, the rotor is a complete separate unit, and both the rotor and the stator core and winding can be supplied as sets for built-in motor or repair purposes. This feature makes it possible to vary the electrical characteristics, using the same set of mechanical parts. The separate-frame construction makes it possible to supply any one of a number of different types of frames as occasion requires. The brackets are bolted to the frame with a ring-groove fit that automatically and permanently sets the air gap and aligns the bearings, thus simplifying the reassembly.



Totally inclosed synchronous motor for service in nitrate plant under dusty conditions

Nitrate Company's Motors Protected Against Fine Dust

Eight totally inclosed synchronous motors were recently supplied by Westinghouse to the Anglo-Chilean Nitrate Company for use in its plant near Tocopilla, Chile. These motors are practically air-tight to exclude the fine corrosive dust of nitrate present in the crushing plant. They are rated at 250 hp., 250 volts, 550 amp., 90 per cent power factor, and are fan-cooled.

Any type of Ford automobile can be thus equipped for service on rails

Adapting the Ford to Rail Transportation

Any passenger, commercial, or truck model of Ford automobile can be adapted for rail transportation, the Brookville Locomotive Company, Brookville, Pa., announces, by the use of the latter's wheels at the rear and its pony truck at the front. A station wagon thus converted is shown in an accompanying cut. The company has just introduced a special line of rail trucks to provide efficient, economical, rail transportation for passengers, freight, express mail, supplies, section gangs, and the like, where local conditions warrant such practice.

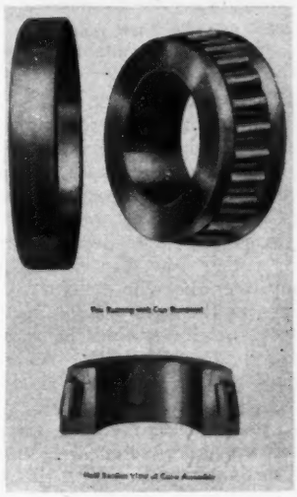
New Tapered Roller Bearings Are Cageless

An accompanying illustration shows a new cageless tapered roller bearing which is being produced in a complete line by the Tyson Roller Bearing Corporation, Massillon, Ohio. All sizes are interchangeable with conventional ball and tapered roller bearings. The principal feature of the design is the absence of a cage or retaining ring. Positive roll alignment is secured by using a double-ribbed backplate at the big end of the rolls, making a cage unnecessary. The shoulder of each roll gets a bearing on the inside rib of the backplate, as in other conventional tapered roller bearings, but it also gets an additional bearing on the outside rib, which is a new feature. Thus, with double contact on the thrust end of each roll, positive alignment longitudinally and vertically is secured. Pintles at both ends of the rolls, extending into annular grooves in the backplate and closing ring, hold the rolls in place when the cup is removed. Omission of the cage from this bearing leaves room, it is said, for from 20 to 50 per cent more rolls than would otherwise be possible in bearings of corresponding sizes with rolls spaced apart. Thus, it is claimed, substantially greater load-carrying capacity is obtained for a given size, as well as greater durability with lower maintenance cost.

Tools Tipped With Hard Alloy Available in Many Forms

A wide variety of cutting tools tipped with so-called "Widia" metal, and of tips of the same material, is made at Essen, Germany, by the Fried. Krupp Steel Works. The name of this material is derived from the German *"wie Diamant"* meaning "like a diamond," the reference being to the material's hardness. Widia metal is made by taking finely powdered tungsten carbide, adding about 6 per cent of cobalt, pressing the mixture into the desired form, and sintering it in a hydrogen atmosphere in an electric furnace at 1,400-1,500 deg. C. At this temperature, the cobalt melts and serves as a binder, the carbide particles being surrounded by it, this greatly increasing the toughness of the resultant material.

For tipping tools the material is generally used in the form of small pieces brazed on to the tool shank. The actual forming of the pieces is possible only at the time they are being manufactured, and their shape cannot be changed by subsequent heat-treatment. Reshaping can be effected to a limited extent by grinding with special wheels.



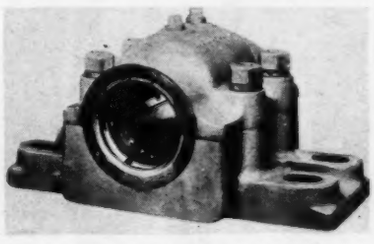
Cage unnecessary with this type of tapered roller bearing

The shanks on which the tips are soldered are made from cast steel containing about 0.5 per cent carbon. High-speed steels are not used for these shanks, as it is difficult to make a good joint on shanks which harden during the brazing operation.

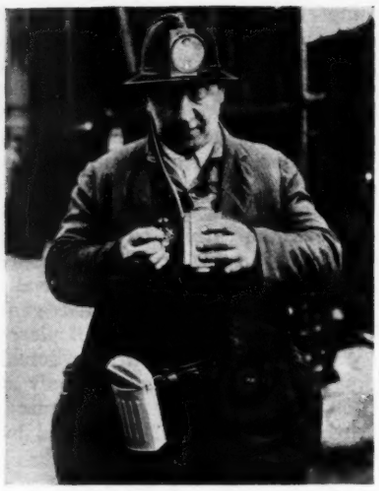
Tools thus tipped are used advantageously for working very hard materials, for machining carburized and case-hardened parts, and for cutting threads in hard materials on which the high-speed steels fail.

An Improved Bearing

Manufacturing and selling rights to the Jones bearing have been acquired by the Robins Conveying Belt Company,



This bearing has an oil reservoir in its base



The miner's "self-rescuer" is quickly available

15 Park Row, New York. This bearing has an ample oil reservoir in its base, from which the oil is drawn up by the rotation of the shaft through a series of ducts or passageways in the bearing metal to the point of the bearing of greatest pressure. From this point, or rather line, the oil is spread uniformly over the whole shaft. Excess oil returns to the reservoir. The bearing is split, the lower liner being rotatable around the shaft. The removable base liners rest in finished saddles and are so designed as to provide strong beams to resist forces resulting from the holding-down bolts when the supporting surface is not true. With this bearing the shaft may be rotated in either direction and may be horizontal or vertical. It can be used for all speeds from 1 r.p.m. to 5,000 r.p.m. It will be marketed as the Robins-Jones bearing.

A Large Magnetic Clutch

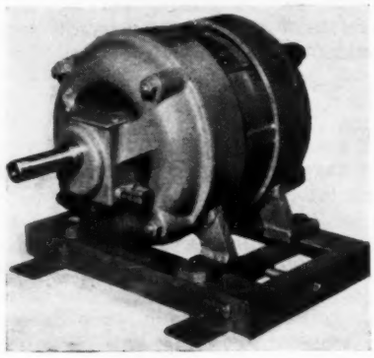
Difficulties previously inherent in large-size magnetic clutches are said to have been overcome in a new multiple-disk magnetic clutch developed by the Magnetic Manufacturing Company, Milwaukee. The new product is a Stearns clutch, which is said to provide maximum horsepower and pull-out torque, and at the same time to have the usual advantages of smaller clutches in ease of operation, smooth acceleration, and low maintenance cost. With a 24-in. clutch it is said that over 6,500 foot-pounds pull-out torque can be developed.

Self-Rescuer Improved

The accompanying illustration shows the improved self-rescuer introduced by Mine Safety Appliances Company, Pittsburgh. It is now arranged in a new air-tight steel case of improved design and is carefully tested for leakage under 10-lb. pressure. Carried on the person as shown and removable in a few seconds, it is always available and ready for use in an emergency. It may also be carried in the pocket.

One-Piece Motor Base

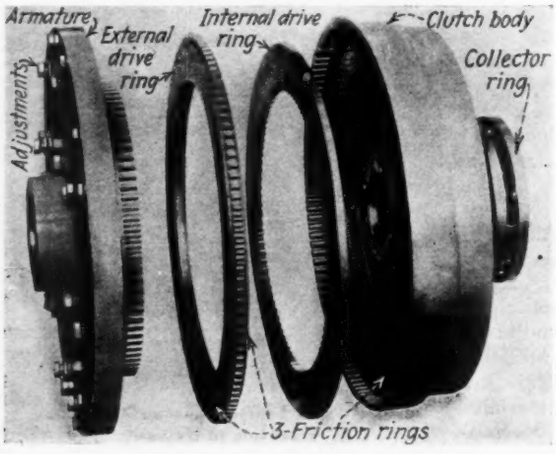
Development of a welded steel one-piece motor base has been announced by the Lincoln Electric Company, Cleveland. This base is intended to be used instead of slide rails. It is made of rolled steel angles and flat bar stock welded electrically into one unit. The flanges of the angles are slotted to permit shifting the motor on the base to tighten the drive belt. In the cut shown, drilled angles may be seen welded to the side to form hold-down lugs for securing the base firmly.



The welded one-piece motor base here shown is a substitute for slide rails

Less Heat With This Light

Elimination of three-quarters of the heat, with negligible loss of light, has been accomplished in a new type of high-intensity incandescent lamp developed in the General Electric Research Laboratory. This has been accomplished by absorbing the heat rays in a liquid surrounding the bulb. Distilled water, a solution of copper chloride, and some other solutions will absorb heat while transmitting most of the light. The heat is conveyed away from this solution by means of a cooling coil through which water is circulated. The new unit consists of a lamp immersed directly in the absorbing liquid, which is confined by an outer glass jacket. The cooling coil, through which the tap-water is circulated, is also immersed in this liquid. Convection currents set up within the liquid are sufficient to maintain a circulation, and no mechanical stirring is required. The lamp, with the cooling coil and outer jacket, is supported from a base plate on which the lamp socket is mounted. Two gaskets make the unit water tight. A safety valve in the base plate permits the absorbing liquid to escape if something happens to the tap-water supply so that the liquid overheats and expands too much.



This magnetic clutch is made in large sizes

Varied Uses for Portable Conveyors

Portable belt conveyors, in sizes ranging from 20 to 60 ft. and with belt widths varying from 20 to 24 in., are being used extensively for handling sand, gravel, crushed stone, mixed concrete, steel scrap, grain, agricultural limestone, and cinders. Other materials are also being handled successfully with certain limitations, including coal and coke for storing and reloading. The conveyors may be had with electric or gasoline power units. A bulletin covering them (No. 41-1) has been issued by the Fairfield Engineering Company, Marion, Ohio.

For Better Welding

General Electric has developed a new heavily coated electrode, Type R, for quality welding. It is composed of 0.13 to 0.18 carbon steel covered with a heavy coating of cotton braid impregnated with an arc-stabilizing flux. It can be had in diameters ranging from $\frac{1}{8}$ to $\frac{3}{8}$ in., 18 in. long. With it an unusual high speed of welding is said to be possible for certain applications, such as pipe-line welding.

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INDUSTRIAL NOTES

Merger of the International Derrick & Equipment Company and the Stacey Engineering Company has been announced. The latter company operates the P. H. & F. M. Roots Company and the Connersville Blower Company. The new company will be known as the International Stacey Corporation and will have headquarters in Columbus, Ohio.

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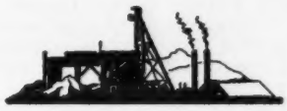
BULLETINS

Flotation. Denver Equipment Company, Denver, Colo. Bulletin 2902, entitled "Accurate Reagent Control."

Speed Reducers and Small Motors. Denver Equipment Company, Denver, Colo. Bulletin 2905.

NEWS OF THE INDUSTRY



Sherritt-Gordon Officials Are Pleased With Mill Results

The first unit of the Sherritt-Gordon concentrator has now been tested under operating conditions and has performed according to expectations, C. D. Kæding, consulting engineer, states in an official report. The unit, which has a capacity of 600 short tons daily, was placed in operation at the property, Sherridon, Man., on March 1. Average grade of ore handled has been 3.5 per cent copper and the indicated extraction has been more than 90 per cent, with the grade of concentrate produced about 24 per cent copper. Zinc is not being recovered. About 70 per cent of the precious-metal content is being saved.

No new development work has been undertaken at the property since the last estimate of ore reserves, which showed more than 5,000,000 tons. The management centered its activities on preparing for production. The main working shaft in the west ore zone has been put down to 680 ft. Stations have been cut at 200, 350, 500, and 650 ft. and drifting has been undertaken on the first three of these levels. The width of ore has been found to be irregular, as drilling results have indicated, but the grade has been as good as expected and will probably average about 3.2 per cent copper, after dilution. Very little work remains to be done to complete the second mill unit, whereas for the third unit considerable equipment must still be installed.

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Big Jim Crosscut Finds Vein

The crosscut on the 500 level of the Big Jim mine, in the Oatman district of Arizona, cut the vein during the last week of April. Where cut the vein was 16 ft. wide, but it carried no ore. Drifting is now under way along the vein in the hope of developing gold oreshoots similar to those being mined from the same vein in the adjoining Tom Reed property. In addition, the shaft is being cleared of débris on the 600 level (its present bottom) and will be deepened to the 900 level, which corresponds to the 1,100 level of Tom Reed. A diamond-drill hole put down by Big Jim indicated ore at 900 ft.

At the Tom Reed, sinking of the winze from 1,100 ft. to 1,300 ft. is now under way. It is already below the 1,200 level. Ore for the mill is still being obtained largely from the 950 and 1,100 levels, the tonnage handled daily being about 125.

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Activity at Silver City, Nev.

H. B. Bulmer, an old-time leaser in the Silver City section of the Comstock Lode, has enlarged and retimbered the incline shaft of the old Milwaukee mine, 2 miles east of Silver City, Nev. An electric hoist and air compressor have been installed. The property was at one time operated by George Wingfield, but has been closed about twenty years. Wingfield relinquished his option, as the owners refused to extend time for payment.

In the early days a considerable tonnage of gold-silver ore was mined. Mr. Bulmer purposes to sink the 250-ft. shaft another 100 ft. and crosscut back to undercut the early orebody. Notwithstanding its name, the ores of the Silver Hill district have a much higher gold content than silver.

Two Silver City mills, the Donovan and the Trimble, are running steadily. The Trimble mill is on custom ore exclusively; and five stamps of the Donovan are on custom ore and five on ore from the Silver Hill mine, controlled by the Donovan Brothers. Two more small mills will be erected at Silver City to treat custom ore, according to a recent report.

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Liquidation of Bob Holdings Expected to Pay Debts

Charles V. Bob, mining promoter, who was indicted on April 28, with Frederick C. Russell, on a charge of using the mails to defraud in the sale of $7,000,000 worth of stock to the public, will pay his creditors within a reasonable time, Joab H. Banton, his attorney, announced after the promoter and Russell had been held in bail of $15,000 each pending trial. Federal Judge Robert P. Patterson, after fixing bail, gave Mr. Banton and Charles V. Halley, Jr., counsel for Russell, until May 11 to make motions for their clients, who pleaded not guilty.

Mr. Banton said that a group of financiers, headed by August Heckscher, had agreed to furnish capital to develop the Bob enterprises. Those included in the group, according to Mr. Banton, are George L. Johnson, G. Maurice Heckscher, George F. Thompson, Floyd L. Brown, and Thomas F. Cole. In return for the relinquishment of Mr. Bob's stock interests and the donation of over $1,000,000, from time to time advanced to Golden Mines, Inc., this group has agreed to furnish the capital necessary to complete the development of the properties, Mr. Banton stated. Mr. Bob has accepted this arrangement, donating his stock holdings in the companies and also agreeing to cancel the indebtedness of these companies to him.

The statement said that Christopher C. Mollenhauer, the receiver, and Francis D. McGarey, attorney for the receiver, have already negotiated on behalf of Metal & Mining Shares, Inc., a contract for the sale or operation of the Consolidated Chromium Corporation properties.

The contract, according to the attorneys, was approved April 8 by Justice May of the Supreme Court, Brooklyn. It is said to provide that the purchaser may at his option acquire the chromium properties of the Consolidated Chromium Corporation for a cash consideration of $15,000,000, or a consideration of $50,000,000 paid on a royalty basis.

Hollinger Reserves Increase; Shaft to Go to 5,500 Ft.

Reserves of ore at the property of Hollinger Consolidated, gold producer at Timmins, Ont., were $48,806,685 on Dec. 31, 1930, compared with $47,819,398 Dec. 31, 1929. The increase was despite extraction of 1,625,449 short tons of ore during the year, from which $10,263,504 was recovered. Included in the reserves are 511,494 tons averaging $12.09 a ton; 2,930,697 tons averaging $8.88 a ton; and 458,864 tons averaging $7.65 a ton.

Results of development work done in the deeper levels have encouraged the management to undertake shaft sinking from the 4,000 level, the present bottom level of the mine, to the 5,500 level. Work is expected to start this year. N. A. Timmins, president of the company, points out in his report that the geological study of the property being undertaken by Dr. L. C. Graton will last three years, of which only about one and a half have elapsed to date.

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Start on Sunnyside Tunnel

Preparations are now being made for driving the new tunnel that will cut the vein at a depth of 900 ft. below the Terry tunnel of the Sunnyside mine of U. S. Smelting, Refining & Mining, near Silverton, Colo. Several men have been added to the force that has been doing development work at the property since the mill shut down last October. Housing facilities for about 60 men have been provided near the tunnel portal.

The new tunnel will be about 10,000 ft. long and will be 8x9-ft. in size. In addition to facilitating development work on the vein at depth, it is expected to make possible a considerable reduction in costs, as it will eliminate the aerial tramway that now connects the mine and mill. According to W. R. Ingalls, present reserves of zinc-lead-silver ore are about sufficient for a two years' supply to the 1,000-ton mill, but the total tonnage that will be available is undoubtedly much greater.

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Wilshire Property to Produce

Development work has been suspended for the time being at the Wilshire property, in Inyo County, Calif., and the flotation plant is being overhauled by Consolidated Metals, the new operating company, preparatory to starting production. An orebody has been opened for a distance of 170 ft. with backs of 270 ft. Ore carries gold. At the quicksilver property operated by the company in San Luis Obispo County, Calif., preparations are under way to increase output from 150 flasks monthly to 165. H. W. Klipstein, re-elected president of the company at the annual meeting in Reno on April 29, states that the mill has four years' supply of ore in sight. Between the 200 and 300 levels, 40,000 short tons of ore have been blocked out, in addition to a large tonnage exposed by a winze from the 400 to 700 level.

Smith Wins Proxy Dispute for Control of Coppermines

Howard D. Smith, president of Consolidated Coppermines, was re-elected president of that organization, which operates copper properties in the Ely district of Nevada, at the annual meeting of stockholders, held in New York City on May 5. Efforts of a group of stockholders, headed by C. K. Blandin, one of the directors, to oust Mr. Smith from the management, because of alleged inability to co-operate with Nevada Consolidated, were defeated, and Mr. Blandin was succeeded by W. B. Congdon as a director of the company. A fight for control of proxies had developed during the last month. The final returns showed 770,043 shares voted in favor of Mr. Smith, and 413,064 shares in favor of the minority group, out of more than 1,400,000 shares outstanding. The minority group claimed that it had the votes of more than 2,000 stockholders.

The chief point at issue was the company's relations with Nevada Consolidated, which owns adjoining properties in the Ely district and which has been treating Coppermines ore in its mill and smelter under a contract made in 1926. Serious litigation is now under way between the two companies concerning the interpretation of this contract. The group headed by Mr. Blandin felt that Mr. Smith's organization, however capable, was so antagonistic to the Nevada management that reconciliation between the two companies was impossible. As Coppermines has increased its ore reserves vastly in the last few years, and as it has no production plant, the Blandin group felt that a new contract should be made with Nevada by which a larger tonnage than the present contracted total of 3,500 tons of ore daily could be treated at the latter's plants. Construction of Coppermines' own plants at present would be far too costly, they averred. Such a contract had been broached by the late David Williams and Frank G. Logan in November, 1930, but it was withdrawn when opposition of the Coppermines board of directors became evident.

Oscar Mitchell, attorney for Mr. Williams' estate, explained at the meeting the attitude of the Blandin group and declared that, even though defeated, the large stockholders in that group would always be willing to support the present management in its continued litigation with the Nevada company and in any other matters in which it acted in the best interests of the stockholders.

J. B. Cotton, director and counsel of Coppermines, then reviewed at length the Nevada litigation and presented the objections of the present management to the contract drawn up by Messrs. Williams and Logan with the Nevada management. Mr. Cotton declared that in his opinion Coppermines should not withdraw from the present litigation. The proposed contract, if consummated, far from settling the matters at issue, would merely have added to them by making concessions to Nevada which he considered unjust. He revealed that the new contract would have provided for treatment of 8,000 tons of porphyry ore and 600 tons of smelting ore daily at what he declared were higher rates.

In connection with the present litigation, Mr. Cotton stated that recent hearing of the Coppermines counterclaims in court at Carson City, Nev., has revealed that in 1926 two sets of settlement sheets were maintained by the Nevada organization and that, as a result, Coppermines was "short-changed" 840,000 lb. of copper. The truth of this charge, he declared, has been proved by cross-examination of Nevada's own witnesses. He said that Nevada men also admit that in the boom period of 1929, the pilot mill section treating Coppermines ore was overcrowded so that recovery was not as high as could economically have been effected. Nevada, in compiling costs for treating Coppermines ore, included $260,000 that should properly have been charged to capital account, he added, but it refused to share part of the capital expense of equipping and sinking the Emma-Nevada shaft of Coppermines, which will eventually handle some Nevada ore. The entire policy of the Nevada company with respect to its Liberty pit workings had been directed first to salvaging the Wedge shaft and then, when it became apparent that the shaft was lost, to delay open-pit working as long as possible, he contended. Mr. Smith had warned Nevada that the location of the Wedge shaft was a poor one and had offered trackage and other rights to permit a safer location, but his warning had not been heeded, Mr. Cotton said. As a result, Nevada lost $1,500,000 spent in equipping and sinking the shaft. He concluded with a warm word of praise for Mr. Smith's administration.

In response to questioning by Robert D. Hoffman, mining engineer, who wanted to know how greatly construction of its own reduction plants would dilute the equity held by present Coppermines stockholders, Mr. Cotton stated that he believed that the plant could be financed by long-term debentures. He added that the plant would not, in any case, be built until better conditions arose in the copper industry and in the financial markets. Such a plant ought to be built by the company, Mr. Cotton declared. Present Coppermines output, he pointed out, is only 65 per cent of its contract tonnage because of depressed copper markets. Mr. Smith added that he thought that hope of arranging a contract for additional tonnage with Nevada was not irretrievably lost. Replying to questions concerning the cost of the litigation to date, Mr. Cotton stated that it was covered by the $74,000 obtained in a decision from the Interstate Commerce Commission on freight rates for mine timber over Nevada's subsidiary railroad.

Mr. Hoffman also raised a question as to the operating costs shown in the report. On the basis of 32,612,000 lb. produced at a cost of 8.88c. a pound and sold for 13.17c. a pound, operating profit should have been $1,300,000, he declared. Instead, the report showed $842,104. Mr. Cotton answered this objection by saying that the balance had gone into deferred development work. Mr. Hoffman declared himself unsatisfied with this response, and wanted to know why, if the extra amount has gone into deferred development, the amounts spent in past development were omitted from the costs.

Although the meeting started at 1 o'clock, the proxies had not been counted until after 10 in the evening. When the results were known, a resolution was moved and adopted praising the administration of Mr. Smith. An attempt was made by W. B. Cravath, vice-president of the company, to include a censure of the minority stockholders, on the ground that they were in the employ of or affiliated with Nevada Consolidated. The suggestion was not adopted.

Another resolution was moved and adopted. It follows:

"Whereas, this company has now developed in its properties over 35,000,000 tons of porphyry ores, besides high-grade ore and, most recently, gold ore of much promise as to extent and richness, which reserves will without doubt be greatly increased as further development is made, and the present contract with the Nevada Consolidated Copper Company for the treatment of the ores of this company is inadequate as to tonnage and inequitable as to treatment charges; and

"Whereas, it appears from newspaper reports of the trial now being had of the suit pending in the U. S. District Court for Nevada between the Nevada company and this company that charges have been made and testimony has been introduced against the Nevada company that it has permitted irregularities in metallurgical settlements and charges and that such practices have prevailed for a considerable period; and

"Whereas, by reason of current low material costs and an adequate supply of both skilled and common labor the present time seems most opportune to proceed with the building of an adequate treatment plant by this company in order that it may be in position to take full advantage of future advances in the price of copper:

"Therefore, Resolved: That the executive officers and the board of directors of this company be, and they hereby are, requested immediately to undertake the necessary studies and to formulate plans with accurate cost estimates for the erection of a treatment plant of adequate capacity for this company.

"Resolved, Further: That said officers and the board of directors be, and they hereby are, requested to formulate a plan for financing the cost of the erection of such a plant and, after due consideration of the question of the erection of such a treatment plant and of proper means of financing the same, their report and recommendations be submitted to the stockholders at a special meeting to be called for the consideration of the same and the taking of such action as the stockholders may consider advisable in the interest of this company."

This resolution was opposed by the minority stockholders.

■

Evolve New Hard Copper Alloy at Montana School

Through research work carried on by H. F. Silliman, research fellow in metallurgy at the Montana School of Mines, at Butte, Mont., and Dr. Curtis L. Wilson, head of the department of metallurgy of that institution, a new copper alloy has been discovered which hardens the copper and gives it great structural strength. This is accomplished by adding 2 per cent of nickel silicide and giving the product progressive heat-treatments. By this process the new alloy has a tensile strength of over 100,000 lb. per square inch, which is four times the normal figure of copper and about 125 per cent of that of structural steel. The process is such that the metal can be pressed or put into the wanted shape before the alloy is hardened. The electric conductivity of the alloy is about 30 per cent less than that of copper.

Amparo Driving Crosscut on Pasadena Mine, Guanajuato

Unwatering of the Pasadena del Monte shaft, adjoining the San Nicolas del Monte property, at Guanajuato, Mexico, now being worked by Amparo Mining, has been completed, and a crosscut is being driven at a depth of about 1,150 ft. to cut the San Nicolas vein system. Amparo will operate the San Nicolas property on a profit-sharing basis with the owners, Atanasio Rocha and partners. The Pasadena claim is held under option by Amparo for three years. Samples taken indicate that the gold-silver ore is amenable to cyanide treatment, and experiments are now being made to determine whether it can also be treated by flotation. J. M. Campbell is in charge of the work.

At the Amparo properties, in Jalisco, the ore reserves are being depleted rapidly, as present low prices for silver do not permit of profitable operation. A total of 2,472 m. of drifting, raising, and crosscutting was done in 1930, and much of the ore milled at Jimenez is coming from this work. No estimate can be made of ore reserves in the Amparo mine itself. In the Mazata mine, which also has its own mill, reserves on Dec. 31, 1930, were estimated at 130,000 metric tons, assaying 660 grams of silver and 3.6 grams of gold per ton. Development has been continued on the 180-m. level of the property. A crosscut is being driven to cut the Rosario vein at that depth.

The Piedra Bola mine, which ships ore to the Amparo mill at Jiminez, had reserves of only 12,695 metric tons at the end of 1930. Average grade was 476 grams of silver and 6.6 grams of gold per ton. Development at depth shows lack of continuity in the grade. Production from the mine in 1930 was only 20,164 tons.

■

Close Granite Mountain Mine

North Butte Mining has discontinued work at its Granite Mountain group, on Butte Hill, in Montana, pending better prices for copper. The company is continuing work on its east crosscut at the Main Range group, where several stringers of high-grade copper ore have been opened on the 2,200 level. The company also is driving a crosscut north, for Anaconda Copper Mining. This crosscut enters ground owned by Anaconda, north of the Sinbad claim of North Butte.

■

Four Killed at Providencia

An explosion of an auxiliary powder magazine on April 24 resulted in four deaths and seven injuries at the Providencia mine of Peñoles, American Metal subsidiary, in the Concepcion del Oro district, Zacatecas, Mexico. Among the injured was E. A. Manderfield, superintendent, but, contrary to early reports, later information is to the effect that his injuries were only slight. Inquiry at the New York office of the company discloses that, so far as known, all the others injured were Mexicans. The chief damage done by the explosion was to the engineering offices of the company. The compressor plant was also damaged, but telegraphed reports indicate that sufficient compressor capacity is available to keep the mine in operation, although at a reduced rate. How long or how serious the interruption will be is not yet known.

■

C. Woods Gets Extension in Selecting Inambari Areas

On April 15, a government decree was issued extending for three years the period within which Clarence Woods is obliged to present an exact plan of the gold concession that he has obtained along the Inambari River, in Peru. This plan must indicate the areas to be selected for exploration, which may not exceed 2,400 hectares each. One drill engineer with equipment is already in the district, and another engineer is en route from San Francisco. Two drills will be operated on the upper Inambari to select areas favorable for dredging and one drill on the lower reaches of the river. Mr. Woods is now engaged in an exploration trip along the river. Aërial photographic survey of the territory will probably not be carried out this year.

■

Copper Range Extends Option on Globe Area in Michigan

The option held by Copper Range on the Globe area, south of the Champion mine, near Painesdale, Mich., is being extended for three years from July 1, 1931. Drilling will be continued along the strike of the Baltic horizon, according to W. H. Schacht, president of Copper Range, in the annual report. During 1930, about $75,000 was spent on underground drilling at Baltic, surface drilling at Globe, and payments on the Globe option. Holes Nos. 82 and 84 drilled on Globe land both cut what is considered the Baltic horizon. Hole No. 82 cut ore in both the West and Main lodes. Hole No. 84 showed some ore. The next two holes will be put down on each side of No. 82. Hole No. 76, between the Isle Royale and Baltic horizon, cut what is considered No. 3 conglomerate and what corresponds to the Baltic and West lodes, just over it. Both these lodes disclose some copper.

Drilling on Champion ground along the Isle Royale lode showed some ore on the footwall side of the lode in two holes. A hole put down to cut the Atlantic horizon failed to cut ore. Underground development during 1930 on the Champion property included 9,833 ft. of drifting, of which 57 per cent was in ore. Development added fully as much ore as was extracted. Copper-production costs were cut slightly in 1930—from 11.758c. a pound to 11.60c. a pound at the Champion mine, before depreciation or depletion. Further improvement in operating costs is expected as a result of adoption of sublevel caving mining methods. With this improvement, Mr. Schacht states, should a price of 10c. a pound of copper prevail through 1931, a small profit would still be expected.

Installation of flotation equipment at the Champion mill is virtually complete, except for some additional filtering and thickening equipment. Expenditures in 1930 included $166,727 for this work and $25,416 for a new roof on the building. A small tonnage of ore from the Baltic mine is still being handled at the mill, in addition to the output of the Champion mine.

Sutro Tunnel Opens New Ore in Crown Point Mine

James M. Leonard, manager of the Sutro Tunnel Corporation, a subsidiary of Sutro Tunnel & Drainage, confirms the report that an orebody estimated to contain $1,000,000, in gold and silver, with full depth of the oreshoot as yet undetermined, has been opened in the Crown Point mine on the old Comstock Lode, in Nevada.

Exploration work has been in progress for two years or more. A tunnel, driven at shallow depth, cut a 40-ft. vein at depth of 125 ft. The grade averaged from $12 to $15 per ton. A second tunnel cut the vein about 100 ft. below No. 1. The grade proved higher at this depth. The vein was then drifted on a distance of 200 ft. with crosscuts every 50 ft. to determine width.

Next a winze was sunk to depth of 100 ft. below No. 2 tunnel level and the vein drifted on nearly 300 ft. Following the dip of the vein, from 250 to 300 ft. of backs is available for stoping. The floor of the drift is still in ore, and no effort has as yet been made to determine the depth of the oreshoot.

During this exploration work 577 tons of ore was shipped to various mills and smelters. Several mills and smelters were tried out in the shipments to determine the process showing the best results. The average of returns on the 577 tons was $19.29 per ton. Manager Leonard states that he does not expect the entire tonnage exposed to average this, as some lean spots will be mined along with the rest, but he does expect average returns of better than $15 per ton. Tests are now being made to determine the best method of recovery. A mill will probably be built. So far tests seem to favor flotation.

■

C. & H. to Develop Kearsarge Through Red Jacket Shaft

Development of the Kearsarge lode in its Calumet & Hecla properties, near Calumet, Mich., will be undertaken by Calumet & Hecla Consolidated through the Red Jacket shaft. Several years ago, a crosscut was driven to this lode on the No. 81 level and some drifting was done, but the ground was not as good as in the company's Ahmeek and Allouez properties, where the Kearsarge lode has been a large producer. However, the recent development of copper ore of good grade in the crosscut on the No. 78 level, at the south end of the Calumet & Hecla unit, and the drifting being done through the Centennial No. 2 shafts on the Nos. 39 and 40 levels, have turned the attention of the management again to the possibilities of the lode in this area. Actual drifting from the Red Jacket crosscut is expected to start about May 15. At present, rails are being laid.

Of its amygdaloid ores, Calumet & Hecla is treating only Kearsarge lode ore by flotation. One stamp unit is equipped for fine grinding of all jig tailings, with recovery of released copper by flotation. The number of units to be so equipped will be governed by Kearsarge lode tonnage and quality in the future. With the new power station at the Ahmeek mill in commission, ample power is available for finer grinding and capacity can be increased as needed. Osceola lode rock does not carry sufficient included copper to warrant flotation. More than 1 lb. per ton is being reclaimed as the result of flotation as applied to Kearsarge ores.

Install Larger Unit at Reno to Test New Zinc Process

Further evidence of the commercial significance of the Maier process of zinc production must wait upon installation of a larger unit at the Reno experiment station of the U. S. Bureau of Mines. The 3-in. tube unit, which demonstrated the feasibility of employing methane or natural gas as a reducing agent, has been dismantled and will be replaced with a 12-in. unit. This will enable E. S. Lever and H. A. Doerner, who are credited with making the first practical application of the discovery of their colleague, to investigate problems that arose in the initial production of zinc by the new method in the first experimental unit.

Press reports that announcement of Maier's invention at this time has dealt a heavy blow to the already distressed industry are regarded as reflecting apparent misapprehension of what is likely to result from its commercial application. Assuming further research will confirm the first demonstration that production of high-grade zinc at a lower cost has been realized in the Maier process, a larger supply of metal that will compete with electrolytic zinc for die-castings seems assured.

Many believe that, in order to pull out of its depression, the zinc industry must offer more lively competition to aluminum and brass. As only a zinc of high purity can capture business from these other metals, the low-cost Maier process of reduction is regarded as opening the door to a new market for many producers whose bins are full of ore that cannot now be converted profitably because of the limited market for spelter produced by the present retort process.

Though present low prices may tend to increase the use of zinc in galvanizing, treatment charges remain high, and the increasing market for zinc alloys remains out of the reach of all except the producers of electrolytic zinc.

■

Attacks British Silver Policy in India at Washington

The British Empire's delegation to the International Chamber of Commerce meeting at Washington, D. C., was sharply split at a group conference on world trade relations on May 5 when S. R. Bomanji, Indian mill owner and delegate of the Indian Chamber of Commerce in Great Britain, denounced the British silver policy in his homeland. The efforts to place India on a gold basis and the "arbitrary" monetary measures taken by British officials had helped to impoverish millions in the poorer classes of India, he declared.

"If you touch silver," he said, "you affect 85 per cent of the 350,000,000 persons in India. Silver is the national savings of these peoples. When you lower its value you take away what they have earned. It is a fallacy to say that silver is only a luxury."

An early adjournment of the conference left no time for members of the English delegation to speak, although one or two indicated that they wanted to make replies in denial. A later opportunity may be offered. After the conference, Mr. Bomanji, who said he had been an emissary for Mahatma Gandhi on several missions in London, described Dr. H. W. Coates, director of Imperial Chemical Industries in England and an earlier speaker at the conference on silver, as "a British government propagandist." He also charged Great Britain with concealing some of its armaments by shifting disbursements to the Indian budget.

The silver discussion was opened by Tsuyee Pei, president of the Bank of China, who offered a new resolution asking for a world silver parley. Action will be taken on the resolution in committee for probable open discussion in plenary session Saturday.

Dr. Coates declared that projects for the stabilization of silver value "are merely attempts to set back the clock and are, in my view, clearly condemned to failure."

■

Bureau Reports Advance in Safety Practice in 1930

Better safety conditions at metal mines in the United States during 1930 are reflected in reports for that year which have been received from mining companies by the U. S. Bureau of Mines, Department of Commerce. Scott Turner, director of the Bureau of Mines, states that although some companies have not as yet sent their accident reports to the Bureau, a sufficient number has reported to indicate gratifying progress in accident-prevention work. A tabulation of returns for 1930, which had been received up to April 18, covering 551 metal mines that were in operation in both 1929 and 1930, shows a reduction of 17 per cent in the accident rate during the latter year. The rate for 1930 for these companies was 182 accidents for each thousand men employed; the rate in 1929 was 220 accidents per thousand men employed.

The fatality rate for these companies was 3.08 per thousand employees, the same as in the previous year, but a substantial reduction was effected in the rate for non-fatal injuries, the figure having been reduced from 217 per thousand employees in 1929 to 179 in 1930.

According to Mr. Turner, the average working period at these mines in 1930 was 285 days per man, compared with 311 days in 1929. The total number of man-shifts worked by all employees at these mines was 18,700,000, about 19 per cent below the level of the previous year. These figures represent companies that employ about 75 per cent of all men working in United States metal mines. Final and more detailed figures covering the entire metal-mining industry will be published as soon as reports have been received from the few remaining companies that have not as yet sent in returns for 1930.

■

New Ore at Buena Tierra

Development during 1930 exposed additional reserves of sulphide ore at the Buena Tierra property, in the Santa Eulalia district, Chihuahua, Mexico, and prospects are considered good for encountering new bodies in depth to the northeast. The mine is operated under lease by Howe Sound, which owns the adjoining Potosi property. Shipments of carbonate ore have been greatly reduced, due partly to failure to find new ore and partly to decline in metal prices. Work on the Nos. 16 and 17 levels, which have been connected with the Potosi workings, has encountered "important quantities of sulphide ores of milling grade," according to G. M. Wasteneys, general manager. A crosscut is now being extended on No. 17 level to the northeast.

■

Cosach, New Chilean Nitrate Combine, Goes Into Effect

A sufficiently large number of nitrate companies have accepted the terms of the new organization, Cosach, to make the merger of the Chilean nitrate industry effective. Under the financing agreement, companies representing 75 per cent of the production were required to agree before the proceeds of the $34,000,000 in bonds floated during April would be made available to Cosach. This percentage has now been fulfilled, and the official expectation is that by July 1, 36 individual nitrate companies will have fallen in line. Anglo-Chilean and Lautaro, the two largest producers, both Guggenheim-controlled, were among the first to accept. Of the $34,000,000 bond issue, $19,000,000 was taken by New York bankers and the remainder was floated in Europe. According to the *Statist*, only 10 per cent of the London issue was subscribed for, the underwriters being obliged to take the remaining 90 per cent. The bonds carry 7 per cent interest. A further $16,875,000 in bonds is being reserved by Cosach for use in acquisition of assets or shares of nitrate companies.

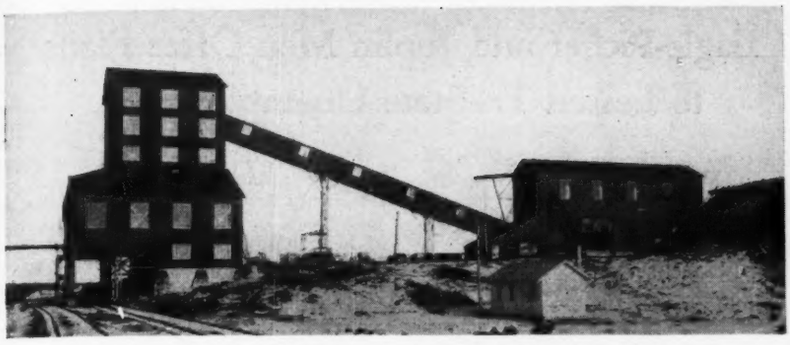
Cosach, or Compañia Salitrera de Chile, will receive from the Chilean government nitrate lands estimated to contain 150,000,000 metric tons of recoverable nitrate, in addition to obtaining the complete assets of all the companies which it absorbs. The Chilean government is also abandoning the export tax on nitrate, which has been one of the most formidable obstacles in the industry's competition with synthetic products. In return, the Chilean government obtains half of the stock issue of Cosach and a guaranteed revenue for the first three years of the operation. Thereafter, it will have to depend entirely on stock dividends. The mining companies which are turning their assets over to Cosach will obtain stock or bonds or both in return. No stock in Cosach is being offered to the public directly.

■

Start New McIntyre Mill

Operation of the new flotation and cyanide plant of McIntyre-Porcupine, in the Porcupine district, Ontario, was expected to begin on May 5. Different sections of the plant have been in the process of tuning up. This new plant, on the same side of Pearl Lake as No. 11 shaft, will have an eventual capacity of 2,000 short tons daily, compared with the 1,500 tons of the present plant. Until the operation has been smoothed out, however, production is likely to be restricted to 1,500 tons of ore.

The effect of application of flotation treatment to McIntyre ores will be watched closely by other Canadian mill operators, both as to costs and recovery. Before undertaking construction of the new plant, the company operated a 100-ton pilot flotation unit for a considerable period.



New Canisteo Cliffs concentrator, near Coleraine, Minn.

Consolidated M.&S. Costs Lowered in All Units

The outstanding feature of operations of Consolidated Mining & Smelting, leading base-metal producer of British Columbia, was the large decrease in cost in every operation during 1930—mining, milling, smelting, refining, and electrolytic zinc recovery. Larger tonnage, technical improvement, and increased effort of the force in general were the causes, S. G. Blaylock, general manager, states in the annual report. Output of all metals except silver and cadmium was higher than in 1929 and the tonnage of ore mined at the famous Sullivan mine increased to 1,924,017 short tons. Grade was lower than in former years, but the recovery, both in milling and in smelting, was better. For the last few months of 1930, mining costs were down to 90c. a short ton, and milling costs to 75c.

Metal prices have dropped so greatly that construction of a second furnace in the new fuming plant at Trail has been postponed. Although designed to recover 115 short tons of lead and zinc daily, operation of the first unit indicates that it will produce at least 125 tons daily when completed—at a cost of about $2,000,000 in plant construction.

Development work at the Sullivan mine has been satisfactory and extensions of ore have been found on the west side of the iron zone in the upper mine. Minable widths of ore, with predominant zinc content, have been indicated 1,000 ft. below the 3,900 level and considerably to the east. Of the controlled properties, development at Coast Copper has been generally disappointing at depth. The grade is erratic and is not maintained for appreciable distances. On the 1,400 level, definite indications have been found of continuation of the 1,200-level bornite oreshoot. A hole is now being drilled west to a granodiorite contact, where conditions seem to favor existence of other orebodies. At the Big Missouri mine, lateral development has also failed to check indications of gold-silver ore obtained in drilling. A 100-ton test mill is now in operation, but it will be several months before sufficient results are available to enable a definite opinion to be formed as to the average grade.

The company examined and reported on 452 properties throughout Canada and the United States, but few of these proved to be of great interest. Development of the Northern Lead-Zinc claims, on Great Slave Lake, consisted mainly of 20,474 ft. of churn drilling. Interesting results were obtained, but further work will be neecssary to trace the trend of the orebodies before estimates of probable tonnages can be compiled. At the Comfort and Bluebell properties, in the Ainsworth district, development indicates possibilities for a substantial tonnage of lead-zinc ore. The company has obtained complete title to all properties, with the reservation that one-sixteenth of operating profits after the outlay for equipment has been returned shall be given to holders of equities in the Comfort option.

■

Dome Increased Ore Reserves While Mill Was Building

The annual report of Dome Mines, Porcupine, Ont., indicates that 1930 was not wasted, even though destruction of the mill by fire late in 1929 prevented production for all but the last two months. Ore reserves at the end of 1930 are estimated at 1,900,000 short tons, grade unstated, compared with 1,300,000 tons at the end of 1929. As Dome handles about 45,000 tons monthly in its new plant, reserves are evidently sufficient for almost four years of operation.

Drifting on the No. 12 level opened a new oreshoot, 165 ft. long, averaging $9.75 in gold per ton over the width of the drift. Boxholing indicates width of ore will be 25 ft. Other orebodies have been intersected on the Nos. 13, 17, and 18 levels. A new stope at the latter depth has a length of 130 ft., width of 30 ft. and average grade of $11.91 per ton. On the No. 23 level, however, crosscutting and drifting failed to discover downward extension of known orebodies.

After the new 1,500-ton mill started, the management found that sufficient treatment time had not been provided. Four additional Pachuca agitating tanks have been installed, and these are expected to increase both capacity and extraction.

■

Falconbridge Resumes Work

Falconbridge Nickel Mines resumed operations on May 4, more than a week in advance of expectations. Repairs for the converter blower, which was the cause of the shutdown, have been completed at the smelter, near Sudbury, Ont. Advantage was taken of the shutdown, which lasted about two weeks, to reline the furnaces, complete assessment work on the claims, and make other necessary improvements at the townsite. The entire force was kept on the payroll at half pay.

Lindsley Believes Opemiska May Becomes Important Property

As soon as transportation is provided, the Opemiska copper deposits, 30 miles west of Chibougamou, Que., should become an important property, Thayer Lindsley states in the annual report of Ventures, Ltd. Details of drill results at this property, which was discovered in 1929, are contained in the report. They show that a total of 22 drill holes have been put down and that all except two have showed some ore. Three zones have been indicated, of which two have a continuous length of about 500 ft. each. The zones lie roughly parallel, with an east-west strike. Holes put down at the east end have indicated continuation of ore beyond the blanks. The ore so far cut occurs in gabbro, with the exception of one hole which showed a narrow width of ore in a ryholite contact. The grade and widths of ore are very erratic, indicating that the deposit is lenticular. Assays as high as 24 per cent copper have been indicated. The company has made no attempt to indicate what the average grade will be. Gold and silver content is relatively high.

In addition to Opemiska and to Falconbridge and Coniaurum, which it controls, Ventures has a 50 per cent interest in the Beattie option, at Duparquet Lake, in Quebec. Diamond drilling is still under way at this property. Ten holes have been put down, of which only the one at the extreme west failed to cut vein material of considerable width averaging more than $1 in gold per ton. One other hole, also at the west end, indicated only 105 ft. of ore averaging $1.44 in gold per ton. With that exception, the other holes showed assays ranging from $2.12 to $4.96 per ton. Widths range from 36.7 ft. to 256 ft.

■

Two New Noranda Holes Add to Reserves Below 1,475 Ft.

The last two diamond-drill holes in the new orebody indicated by drilling below the 1,475 level of the Noranda Mines property, Rouyn, Que., increase the apparent length and width of the orebody, showing high-grade copper over good core lengths, J. Y. Murdock, president of the company, has stated. This ore is directly under the "H" orebody. Although gold content is somewhat lower than that in the holes reported on at the recent annual meeting, the new development apparently increases the tonnage of fluxing ore.

Mr. Murdock reiterated his earlier statement that Noranda is essentially a copper property and not a gold mine, and denied the rumor that the company was contemplating construction of a cyanide plant to handle gold ores. The two latest holes referred to are about 300 ft. apart and are understood to have reached ore at around 2,200 ft. below the surface. Station cutting is under way on the 2,000 level now, and a crosscut will be started toward the new ore in about a month.

Noranda produced its first finished product in its own plant on May 4, when initial wire bars were cast at the Montreal East refinery. The first shipment of these bars, Noranda's final product, will probably be sent to the fabricating plant of Canada Wire & Cable, which Noranda controls and which has built a plant adjoining the refinery.

Sunshine Crosscut at 1,700 Ft. Shows Two Shoots Close

Crosscutting on the 1,700 level of Sunshine Mining, largest silver producer in the Cœur d'Alene district, Idaho, indicated that the Yankee Boy and Polaris or Sunshine oreshoots are separated by only 8 ft. of waste rock and lends credence to the theory that these oreshoots will merge at depth. The 1,700 level is 450 ft. on the dip of the vein below the 1,300 level, where the last development work was done.

The crosscut entered the Yankee Boy oreshoot 156 ft. from the main hoisting shaft. There the ore occurs in two streaks, both about 15 in. wide, in a vein width of 5½ ft. The entire width will probably be mined and is expected to average about 20 oz. of silver per ton. After 8 ft. of waste, the crosscut showed the Polaris vein to be 9 ft. wide, of which 4 ft. on the hanging wall is high grade. The entire 9 ft. may average as high as 50 oz. per ton.

Drifting east and west along the veins is now under way. On the upper levels, ore has been proved over lengths of 1,400 to 1,600 ft. In addition, west of the shaft, a narrow high-grade lead stringer was followed for about 500 ft. on the 1,300 level. It occurs between the two main oreshoots. Its rake indicates that it may be found about 150 ft. west of the crosscut on the 1,700 level.

■

Mid-West Zinc Mines Curtail

Further curtailment in zinc production from the Mississippi Valley mines has been announced within the last two weeks. The mines at Platteville, Wis., which have been steadily declining in importance for several years, are cutting production 50 per cent. In the first four months of 1931, production was about 8,000 short tons of concentrate, compared with 9,200 tons in the same period of 1930.

In the Tri-State district, Kansas Explorations, subsidiary of St. Joseph Lead, has closed all its mills and mines. With the closing of these properties, only locally owned mines are still in operation in the district, all the other properties owned by outside interests, such as Federal Mining & Smelting, having been closed.

On May 7, word was received that 16 mines have shut down until prices advance. Weekly output is reduced by about 1,650 tons and only 18 companies, operating 36 mines, are still producing at about 5,000 tons of concentrate weekly.

■

New Tunnel at Midnite Test

As soon as plans are completed, a 6,000-ft. tunnel will be driven along the Midnite Test vein, in the Groom Creek district, near Prescott, Ariz., by National Exploration. The tunnel will run north and south along the vein and will connect with the several shafts that have been sunk on the property. It will be a double-track tunnel, with a drainage ditch in the center. The Midnite Test shaft will be cut at a depth of 550 ft., the Nevada shaft at 630 ft., the Gazelle at 800 ft., and the Gold Note at 1,130 ft.

Operations at Midnite Test have been continuous since 1928. A 50-ton mill is now in operation on the ore, the metal content of which is predominantly gold. A much larger mill may be built at the tunnel portal when the tunnel has been completed.

Eagle-Picher and Joplin Men Offer Plans to Lessen Tri-State Unemployment

"Back to the gouges!" could be the slogan of Tri-State mining men in their efforts to provide employment for idle miners in the Joplin zinc and lead fields. Eagle-Picher Mining & Smelting has approached citizens of Galena, Kan., 7 miles west of Joplin, with a proposition that would dewater the old shallow lead-mining sections of that district and provide work for hundreds of idle miners. For many years, or almost since the inception of mining in the Tri-State area, the Galena mines were prolific producers of lead at shallow depths. Development of the larger and richer orebodies of the Oklahoma and other districts, coupled with a huge demand for zinc and lead concentrates from the Middle West, increased the demand and the wages of miners, with the result that the old Galena workings, once filled with water, have lain idle for many years.

Decreased production of lead concentrate, following the spending of almost $250,000 at the Galena smelter of Eagle-Picher, forced this plant to work greatly under capacity. This need for lead concentrate, combined with a desire to aid in putting idle miners back to work, has brought about a proposition by the Eagle-Picher to the citizens of Galena to the effect that Galena raise between $2,500 and $5,000 for building necessary flumes and dikes around old mines in the Short Creek district. These would keep flood waters out of the old workings. The money would also be used to procure leases on several thousand acres of land. In return Eagle-Picher volunteers to unwater the lands and sublease the properties to small mining outfits.

Eagle-Picher is not interested in making a profit from the increased royalties beyond that of paying for the unwatering expense. Increased supplies of ore and concentrate to its plant would be sufficient recompense for its efforts. John I. McClaren, manager of the Galena plant of Eagle-Picher, a resident of Galena for more than a quarter of a century, sees in the idea a further increase in employment at the smelter as a result of the larger intake of lead ore and also employment of hundreds of idle miners and resuscitation of prosperity to his home town as a result of the increased employment.

In Joplin, forty or fifty of the leading citizens, headed by George Meese, an old-time mine operator of Joplin, who has developed several shallow mining camps, have formed the Joplin Mining & Development Company, with a capital of $10,000, which is to be used in drilling shallow mining tracts for the purpose of subleasing these to individual miners. The company hopes to obtain sufficient revenue from the increased royalty to keep several drill rigs busy developing mines for small operators.

The Joplin Chamber of Commerce has appointed a mining committee, which is seeking to obtain tracts on which shallow mines are known to exist for small prospectors. The chamber is not leasing properties, but hopes to form a sort of clearing house whereby land owners and prospectors can be brought together and also to bring individuals together who may have equipment or money which if combined would be sufficient to start a prospect.

The object of these moves is to stimulate the mining for shallow lead ore. Little zinc would be recovered by these operations, for little zinc ore is found at shallow depths, and even those deposits found would hardly afford living profits for the miners at present prices.

Probably 1,000 miners are now operating small prospects in various parts of the district. Some are making a fair wage out of these prospects, but others are able to eke out only a bare existence. About 3,000 miners of the district are out of employment, and many of these are anxious to prospect for shallow lead orebodies, but haven't the necessary financial support. Hand windlasses, horse hoisters, buckrocks, hand jigs, and sluice boxes are again in vogue and are the means of livelihood for many miners of the district.

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Interest in Gold Properties in California Grows

Continued attention is being directed toward gold-mining possibilities in California. A rumor is in circulation to the effect that Calumet & Arizona representatives are investigating some Mother Lode properties. Local efforts are being directed toward old drift-mining properties as well as lode claims. The Blue Point property, at Smartsville, Calif., is being reopened by Blue Point Gravel Mines, of which F. A. Beauchamp is managing director. River Placers, Ltd., is operating a property on the Yuba River between Alleghany and Nevada City. Charles Preston and J. Donovan have opened up a gravel deposit by shafts on the south fork of the Calaveras River. Many individual workers have taken to sluicing and crevicing in the old placer areas.

The success of Mountain Copper in working its low-grade copper-gold gossan deposit at Iron Mountain, Shasta County, has attracted attention to other gossan deposits in the Shasta region. The gossan deposit at the Mammoth property is being investigated and sampled. Near the Balaklala property is another gossan. Vickery Brothers are reported to be investigating a gossan deposit at the Golinsky property not far from Mammoth.

At the Kennedy mine, near Jackson, arrangements are understood to be under way to complete flotation equipment of the mill for treating the residue and to use flotation eventually to treat the ore. Vena Madre Metals is unwatering the 587-ft. shaft of the South Jackson mine, near Jackson, and will investigate the workings. L. E. Schneider is in charge.

Amador Star Mining has completed mine drainage operations at its property north of Plymouth and is exploring the 230 and 300 levels of the 580-ft. shaft.

A 155-ft. shaft at the Quartz Mountain property, north of Sutter Creek, is to be sunk an additional 50 ft. before drifting is started. A. Callison and J. R. Murphy control the property. North of the Quartz Mountain property, C. Brockman has bonded 109 acres and has started shaft sinking.

BRIEF NOTES

Arizona Asbestos Association. On May 1, the property at Chrysotile, Ariz., was closed down because of the low prices of asbestos. About 100 men were affected. The property was the largest producer in the state. The deposits lie nearly flat and have been developed by tunnels. Hand cobbing, both in the stopes and on the surface, produced clean fiber, which was shipped by truck from the mine to the railroad at Rice, a distance of 42 miles.

Arlington-Relief Mines. At a recent meeting of the shareholders, decision was made to resume development of the properties, on Erie Creek, in the Nelson district, British Columbia. About $23,000 in gold bullion and concentrate was reported to have been produced in 1930. If development warrants, a flotation unit may be added to the mill.

California-Alder Gulch. The company, operating near Virginia City, Mont., has 21 men on its payroll, according to Frank Zichosch, general manager. Six of these men are prospecting in the placer deposits about half a mile south of Virginia City and have erected a 60-ft. sluice box. At the quartz mines, on the west flank of Alder Gulch, a new vein has been opened, said to be 8 ft. wide and carrying a good grade of gold ore.

Central Idaho Mining & Milling. Construction of a 50-ton flotation plant has nearly been completed at the company's War Eagle mine, near the Salmon River, in central Idaho, according to W. F. Newton, manager. A high-grade gold concentrate will be made and will be shipped to the Bunker Hill smelter at Kellogg, Idaho, after operations start in July. The mine has been developed by tunnel to a depth of 720 ft., connecting raises having been put up to the surface. Three oreshoots are expected to provide mill feed. The company has its own 350-hp. hydro-electric plant. About $55,000 has been spent since acquisition of the property from an Iowa operator.

Colorado Fuel & Iron. Diamond drilling at the Sunrise iron mine, Sunrise, Wyo., was started on April 28. Sullivan Machinery Company is doing the work under contract. Exploration work of a similar nature has been carried on at the Orient property for the last few weeks, using company equipment. All drilling at the Sunrise, however, will be done from the surface, whereas at the Orient mine, the drills were placed underground. J. B. Stone, company geologist, is in charge of the work.

Golden Chariot-War Eagle Mines. Work will be started immediately, according to an announcement of the company, at the properties near Silver City, Idaho. Engineers Exploration, after a careful investigation, has decided to make a substantial investment in the company's shares. (Capitalization is $1,000,000 in $1 shares.) W. R. Wade, of the Engineers Exploration staff, has been elected president. A large producing gold mine is the object of the present development work.

H. W. Gould Company. The Mahoney quicksilver property, San Luis Obispo County, Calif., 14 miles west of Paso Robles, has been acquired by the company. Tentative plans are for equipment with a Gould rotary furnace. The property was first worked in 1870, and since then has been operated intermittently.

Hudson Bay Mining & Smelting. In the first quarter of 1931, the company's mill, at Flin Flon, Man., treated about 250,000 short tons of copper-zinc ore, according to R. H. Channing, Jr. Operating costs during that period were about $3.60, indirect charges were about 90c., and net revenue per ton was about $4.90, Mr. Channing stated, indicating a profit of 40c. a ton. The gold content of the ore handled to date has been higher than the official estimate. Mill recoveries have been improved slightly since the beginning of the year, but are not yet considered satisfactory. Zinc is being sold at a premium.

I. B. Mining. Operation of the company's cyanide plant for the treatment of gold ore at the property, Bannack, Mont., has been started. About 35 men are now employed under the direction of I. B. Haviland, of Chicago, Ill. An 18-mile power line was completed to the property late in 1930.

Jack Waite Mining. Although reports that the property, in the Coeur d'Alene district, Idaho, was closing are incorrect, production has been curtailed. The new 500-ton mill, completed in February, had been handling about 400 tons of lead ore daily, and, in addition, a considerable tonnage of high-grade ore for direct-smelter shipment was being mined. The extent of curtailment has not been announced. It went into effect on May 1. Raising from the main tunnel, which has its portal in Idaho, to reach the Montana tunnel is now nearly completed. The tunnels are about 400 ft. apart vertically, but about 600 ft. on the dip of the vein. A shaft is also being put down on high-grade ore from the main tunnel level.

Kirkland Lake Gold. A new and unexpected discovery of ore has been made at the mine, in the Kirkland Lake area, of Ontario, in a drift which has just been started west on the 2,500 level, and which will connect with the new shaft on the adjoining property, owned by Macassa Gold Mines. The ore is quite rich and was found while slashing around an old stope which had caved in. The face of the drift has still some 300 ft. to go before crossing into Macassa territory. In its main shaft Kirkland Lake Gold Mine has reached a depth below 4,600 ft. and is continuing to the 4,800 level.

Lake Shore. At the mine, in Kirkland Lake, Ont., a 200-ton plant is being installed at the mill for the practical demonstration of laboratory results of experiments in re-treating tailing. The American Cyanamid Company is installing this unit. Its success will mean a saving of at least $1 a ton in gold recovery from Kirkland Lake mines. The process, details of which are not yet available, is understood to include chemical treatment of tailing after cyanidation.

Ledoux & Company. This well-known firm of assayers has moved its quarters from 99 John St., where it has been for the last 50 years, to newly equipped laboratories and offices at 155 Sixth Ave. The new quarters are declared to be among the best equipped commercial laboratories in the United States.

Moffatt-Hall Gold. Equipment and supplies have been moved to the property, in the eastern section of Kirkland Lake, Ont., preliminary to starting on the first stages of its proposed program of underground development. Sinking will start on May 1 on a 150-ft. shaft, with further plans, according to the contract, for 250 ft. of lateral development work when this depth is reached. The shaft is about 800 ft. south of the Bidgood Consolidated No. 2 shaft in an area that has been cross-trenched for 500 ft. and that was probed by diamond drilling two years ago.

Montana Mines. Development of ore on the 500 level of the Spring Hill mine, near Helena, Mont., is being continued. The grade is said to average $7 in gold per ton, compared with an average of about $5.40 obtained from ore in the upper workings. Production is still at the rate of about 7,000 short tons monthly. Drifting on the vein at the 500 level, which is 200 ft. below the main producing level, is now being undertaken both east and west of the shaft.

Mother Lode Coalition. Although 3,787 ft. of drifting, crosscutting, and raising was done at the property in 1930, and 2,981 ft. of diamond drilling was accomplished, no orebodies of any value were discovered, Charles Earl, president of the company, states in the annual report. Mother Lode has been looking for new ore for several years without success. Although the tonnage mined in 1930 was less than half that mined in 1929, the grade increased from 11.14 per cent copper to 20.31 per cent.

Stillaguamish Mining. The company is driving a 700-ft. tunnel to cut its "central" vein at a depth of about 400 ft. at the property, near Granite Falls, Snohomish County, Wash., according to E. G. Howe, president. Two shoots have been cut in driving the tunnel. Copper, gold, silver, and lead occur in the deposit, according to Mr. Howe. The property is being operated under a twenty-year lease and includes 180 acres of mining ground. Railroad transportation and electric power are available.

United Verde Extension. At the Vulture mine, which it is operating under option near Wickenburg, Ariz., the company is crosscutting and drifting on the 500 level, according to an official statement by James S. Douglas, president of the company. The shaft "is in ledge matter of no commercial value," the statement, dated May 1, declares. Although the vein was cut early in April, and there have been rumors of high-grade ore having been found, this statement indicates that no ore has yet been developed.

Yellow Pine. Installation of equipment preparatory to sinking a shaft in the company's Meadow Creek tunnel, near Stibnite, Idaho, has been completed. The shaft will be put down 410 ft. and will eventually connect with the Monday tunnel, which is being driven on the Meadow Creek vein, at a point about 8,000 ft. from its portal. The Meadow Creek tunnel cuts the gold orebodies about 400 ft. below the surface. The company's 525-kw. hydro-electric power plant on Meadow Creek has been completed.

Wheeling-Lordsburg Copper. This company has been formed in West Virginia, with a capitalization of $1,000,000, to take over the property of Anita Copper, at Lordsburg, N. M. The change was made because, although controlled in West Virginia, Anita Copper was incorporated in California. Development on the 800 level of the property is said to have shown a vein width considerably greater than on the 700 level.

EXCLUSIVE

CABLES

FROM CORRESPONDENTS IN THE PRINCIPAL MINING CENTERS

Broken Hill Mines Resume Recovery of Zinc Content

Melbourne, April 25.—Production of zinc concentrate was resumed at the North Broken Hill and Broken Hill South lead mines, in New South Wales, on April 20. This action follows reduction in the railroad freight rate on concentrate from Broken Hill to Port Pirie by 3s. 6d. per ton and the increase in the exchange rate since the cessation, about the middle of 1930. Inasmuch as the value of Australian currency has dropped, while wages and many other costs have dropped, and for the reason that Australian metal production is sold on the London market for English currency, the Broken Hill mines have, in reality, been able to take advantage of a large cut in their production costs. The two properties, when operating at a normal capacity, have a combined output of about 3,000 long tons of zinc concentrate weekly. Zinc Corporation, third of the large Broken Hill mines, produces about 1,000 tons weekly.

. . . . Starting today, April 25, Zinc Corporation plans to suspend its operations one week in four. Some time ago the management gave notice of intention to suspend completely on this date, but because of the hardships that it would involve on the workers, and because of the precarious financial condition of New South Wales, the company is adopting this means of curtailing, without, at the same time, increasing its operating expense per ton, as, presumably, production will be maintained at capacity during the periods of operation. About 900 long tons of ore is treated daily.

. . . . The shale oil investigations which the Broken Hill companies were making on the Newnes field, in New South Wales, have been suspended for the time being because of the depression. The companies had floated Shale Oil Investigation, Ltd., with a capital of £100,000, to determine the possibilities of recovering sufficient oil to furnish the new central diesel-engine power plant being erected at Broken Hill. Estimates placed the total shale available at 20,000,000 long tons, carrying 70 to 120 gal. of oil per ton.

. . . . A gold nugget weighing 75 oz. has been found at Creswick, Victoria, by two forestry students. It is valued at £370. There has been considerable activity in the neighborhood of Creswick by unemployed prospectors, and nuggets up to 21 oz. in weight have been found within the last three or four months. More than 4,000 gold prospectors, supported in part by the government, are working on old fields throughout the state (see also Australian letter on p. 320). A governmental report by H. W. Gepp and William Baragwanath, of the state geological survey, covering the Bendigo gold field, recommends expenditure by the federal government of £50,000 in developing this district. They propose underground exploration of the area parallel to the main auriferous reefs, which were exhausted by earlier operators.

. . . . For the quarter ended March 31, Mount Lyell Mining & Railway, operating the only large copper producer in Australia, treated 62,619 long tons of ore. From this, 10,155 tons of concentrate, 2,410 tons of copper, 36,155 oz. of silver, and 940 oz. of gold were produced. This is about the same rate as in the previous quarter.

. . . . Carl O. Lindberg, consulting engineer of New Consolidated Gold Fields, who has been in Australia examining the Lake View & Star and Wiluna properties, in which his company has a large interest, confirms the ore-reserve estimates made for Wiluna Gold, the new enterprise near Meekatharra, Western Australia. The company has stated that a supply of ore sufficient for seven years of operation is in sight—capacity being about 500,000 long tons annually. Mr. Lindberg also confirms estimates of profit and states that all sections of the mine and plant are functioning satisfactorily. From March 3 to March 31, the mill treated 14,417 long tons of ore, averaging 32s. in gold per ton. This compares with an average estimated grade of 39s. The first clean-up was made in the middle of April.

. . . . Mount Isa, dispatches from Queensland state, is expected to start crushing on May 1. The company is employing 1,000 men. Its plant, which includes a lead-zinc concentrator, lead smelter, and power house, covers an area of 35 acres.

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Mufulira Increasing Speed

London, May 1.—Early delays in making underground openings at the property of Mufulira Mines, in Northern Rhodesia, have now been fully overcome, the company states, and rapid progress is being made in putting the orebody into condition for production. Rhokana Corporation, having completed its drilling campaign, reports no development of particular significance but pleasing progress in construction work at its N'Kana, N'Changa, and N'Changa West Extension mines.

. . . . Charles R. Wraith, American metallurgist, formerly with Anaconda Copper, is leaving London to take charge of the new smelter at Roan Antelope. Construction is now nearly completed and the concentrator is expected to be in operation within a short time.

. . . . The copper "segregation" plant at the Alaska mine, in Southern Rhodesia, is in operation and is making an extraction of 90 per cent of the copper content of oxide ore in a high-grade concentrate, suitable for smelting. The "segregation" process has been evolved by Minerals Separation for the treatment of Rhodesian oxide and mixed oxide-sulphide ores, and involves roasting prior to flotation. A similar plant with a capacity of 350 tons of ore daily is being constructed for Union Minière.

Kolar Mines' Output Affected by Serious Rockbursts

London, April 30. — At the annual meetings of the several companies operating in the Kolar district, Mysore, India, that have been held during the last month, the chairmen of the boards of directors brought out the fact that serious rockbursts, resulting from the great depths at which operations are carried, and labor troubles are adversely affecting operations. Production from the Kolar field in 1930 was 328,242 oz. of gold, the lowest it has been in many years. A strike last April meant the loss of almost one month's output. In the first quarter of 1931, production was 88,133 oz. This decrease in production does not reflect the ore-reserve situation, as at least two of the five producing mines—Champion Reef and Nundydroog—have developed high-grade reserves within recent months.

. . . . Consolidated Diamond Mines of South-West Africa, one of the Anglo American group, reports profits in 1930 of £366,530, compared with £582,456 in 1929, before deduction of depreciation or debenture interest. The value of diamonds held by the company increased 23 per cent during the year to £525,000. This represents cost of production of diamonds held. Enormous diamond stocks are now in the hands of the Diamond Syndicate, the government of the Union of South Africa, and the Diamond Corporation. At present, no likelihood is seen of being able to liquidate these holdings within a short time.

. . . . Tigon Mining & Finance, which holds sulphur and base-metal properties in Spain and a sulphur property in Chile, is offering 108,000 unissued shares of stock at 10s. However, as the company has made frequent stock offerings in the past (most of them at £1 a share or more) and results have been negligible, the offer is not regarded as attractive in London. The company's capital was originally in 200,000 shares of £1 par, but is now 800,000 shares of 5s. par, of which 649,880 shares were issued on Dec. 31. No detailed information is available about the company's sulphur property in Chile, although it has been producing a small quantity of sulphur—from 5,000 to 10,000 tons of refined sulphur annually.

. . . . Union Minière, Belgian Congo copper producer, is paying a dividend of 240 fr., gross, on its capital and dividend shares, and on its privileged shares it is paying the usual net dividend of 30 fr. plus 140.8 fr., gross. In 1930, the company paid a dividend of 300 fr. per share on the capital and dividend shares, and 30 fr. plus 176 fr. on the privileged shares. There are 300,000 privileged shares, 264,000 capital shares, and 264,000 dividend shares outstanding. The gross dividends are taxable, but the net dividend on privileged shares is tax free. The company has a balance of 60,000,000 fr. to carry forward, compared with 31,710,680 fr. carried forward in the accounts last year.

MARKET AND FINANCIAL NEWS

Anaconda's 1930 Earnings Down 27 Per Cent

In 1930, Anaconda Copper reported net income of $18,782,968, after all charges except depletion. In 1929, net income was $70,317,739. In 1930, gross sales and earnings were $179,332,798. In 1929, gross sales and earnings were $305,751,876. In 1930, operating profit was $28,429,492. In 1929, it was $81,779,412. These figures include the subsidiary companies in Mexico, Chile, and Poland. They also include manufacturing subsidiaries. The consolidated surplus account, which, at the beginning of the year had been $112,033,553 (minority interests in subsidiaries not included), was $87,442,901 at the end of the year. Of this shrinkage, $8,693,133 went into a fund for adjustment of inventories.

Production of copper, including custom ore and ore treated on toll, was 647,411,665 lb. In 1930 it was 990,569,463 lb. Production of electrolytic zinc in the United States was 226,555,255 lb. (compared with 273,357,416). Zinc in dross and residue amounted to 5,918,479 lb. Production of lead by International Smelting, a subsidiary, was 107,860,121 lb., entirely custom ore. In addition, 14,459,634 lb. of lead was contained in zinc dross and residue. Silver production included 7,591,779 oz. from copper operations, 2,538,407 oz. from zinc operations (of which 341,606 oz. was recovered in copper plant), and 4,543,645 oz. from lead operations. Gold output included 85,356 oz. from copper operations, 7,603 oz. from zinc, and 28,300 oz. from lead. Byproducts included 988,204 lb. of cadmium, 485,780 lb. of nickel sulphate, 480,246 lb. of copper sulphate, 9,693 tons of arsenic, and 49,356,906 lb. of zinc oxide. Manufactured products of American Brass and Anaconda Wire & Cable totaled 701,048,368 lb. Silesian-American Corporation, Polish subsidiary, produced 158,859,896 lb. of zinc and 19,247,496 lb. of lead.

The balance sheet on Dec. 31, 1930, showed total assets of $739,105,795. Of this $584,271,190 were fixed assets, including $26,295,923 in investments in sundry companies. Current assets totaled $143,183,303, of which nearly half, or $68,033,234, represented metals and manufactured products in process and on hand. They were valued at cost, less the contingent reserve to which reference was made in the foregoing. Metals on hand at the end of 1929 were valued at $84,655,074. Anaconda's current liabilities total $70,054,516, of which $47,500,000 is notes payable. In addition, the company has $37,110,000 in bonds outstanding, of which $35,000,000 are Chile Copper 5 per cent debentures, due in 1947. In addition, and not shown on the balance sheet, Silesian-American Corporation had $10,441,000 in outstanding bonds on Dec. 31, 1930, compared with $11,512,000 at the end of 1929.

E.&M.J. Weighted Index of Non-Ferrous Metal Prices

100 Is Composite for 1922-3-4

1920	130.92
1921	80.80
1922	93.94
1923	103.43
1924	102.63
1925	111.74
1926	107.74
1927	97.54
1928	99.78
1929	110.33
1930	82.87

	1929	1930	1931
January	106.86	102.94	67.62
February	110.37	102.28	65.90
March	122.71	99.93	68.03
April	116.36	93.24	64.45
May	110.03	83.41	.....
June	109.66	78.57	.....
July	109.58	74.58	.....
August	109.81	74.41	.....
September	109.29	73.42	.....
October	108.52	69.63	.....
November	106.09	71.39	.....
December	104.75	70.65	.....

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Financial Notes

TECK-HUGHES GOLD, operating in Ontario, reports a gross income of $2,693,600 in the six months ended Feb. 28, 1931. Operating costs were $967,623, leaving operating profit of $1,726,000. Taxes and depreciation allowance leave a surplus, available for dividends, of $1,469,400.

ALASKA JUNEAU reports estimated results for March, 1931, as 368,790 tons mined and trammed; receipts $343,500, or 93.14c. per ton; operating expenditures $203,500, or 55.18c. per ton; operating profit $140,000, or 37.96c. per ton; other expenditures $3,750, leaving $136,250 to surplus for the month.

Silver Production Shows Downward Trend

United States production of silver during March totaled 3,562,000 oz., against 3,187,000 oz. in February, and 4,998,000 oz. in March, 1930, according to the American Bureau of Metal Statistics. Production of silver in this country in the first three months of the current year amounted to 10,229,000 oz., against 14,912,000 oz. in the same period last year.

Canada produced 1,429,000 oz. in March, against 1,772,000 oz. in the preceding month, and 1,714,000 oz. in March last year.

Peru's output of silver in March was 1,056,000 oz., against 1,047,000 oz. in February, and 1,460,000 oz. in March, 1930.

Latest figures on Mexico's production cover the month of February. In that month the output was estimated at 6,944,000 oz., against 8,751,000 oz. in January of the current year, and 12,717,000 oz. in February, 1930.

World production (about 87 per cent of total output) during February was 14,137,000 oz., comparing with 16,316,000 oz. in January and 21,849,000 oz. in February, 1930. February production in 1930 was the high for that year. The monthly average for last year was 17,619,000 oz.

Silver production by countries in thousands of ounces, for the first three months of the year, follows:

	Jan.	Feb.	March
United States	3,480	3,187	3,562
Canada *(a)*	1,932	1,772	1,429
Mexico	8,751	6,944	(b)
Peru	918	1,047	1,056
Australia	695	657	704
Burma	540	530	(b)
Totals	16,316	14,137	....

(a) Incomplete; silver contained in blister copper and lead bullion exported omitted. *(b)* Not yet available.

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TEXAS GULF SULPHUR reports net income of $2,448,198 in the first quarter of 1931, after depreciation and taxes. In the corresponding period of 1930, net income was $3,803,701.

AMERICAN METAL, smelting and mining company with interests in Mexico, the United States, and Canada, reports net profit of $108,392 in the first quarter of 1931, after taxes, depreciation, and reserves. This compares with $773,372 in the first quarter of 1930.

Some Figures on Copper—Sales, Stocks, Output

S. D. Strauss
Assistant Editor

Comparative statistics are always interesting, and particularly when they apply to matters such as the average price received by competing concerns for the same product. In the accompanying table are published some figures concerning production, sales, and stocks in 1929 and 1930 contained in published reports of leading copper companies. As in all other matters, the reports vary widely in the completeness with which they publish figures on these aspects of their business. Some of the figures in this table were not contained in the reports at all, but were obtained by calculating on the basis of those actually published. When, for instance, a copper company operating in the Michigan district gave the average price received for its copper, but not the total amount of its sales, the price was divided into the total revenue from metals and the resulting figure was accepted as the sales of copper, as the value of byproducts in Lake copper is slight. As a result, of course, some figures in this tabulation may not be strictly accurate, but they have been marked as unofficial, and it is believed that the variation in any case will not prove large.

Another difficulty crops up in determining precisely what constitutes stocks of metal on hand. Should it include copper in process or only metal actually available for sale? Some companies list these two items separately. In other cases, the value of all metal not actually in the ground is given. Wherever possible, the figures used in the columns on stocks of metal are for metal available for sale, but where these have not been published, the company's practice has been followed.

Still another respect in which the reports vary is in the practice of estimating revenue for a given year. Utah Copper, Nevada Consolidated, Miami Copper, and Consolidated Coppermines use their entire production—whether sold or not—as the basis of determining revenue. But the value which they place, per unit of metal, is the actual average price received on sales. Thus, in 1930, Utah states that it produced 161,138,717 lb. of copper, valued at 11.915c. per pound, and credits itself with $19,199,356. Nevada, of the same group, produced 141,980,173 lb. of copper, but values it at 12.207c. per pound. Obviously, therefore the figures given are actual prices received. Calculations to determine the amount of stocks on hand, however, indicate that Utah actually sold 190,737,373 lb. of copper in 1930 (if the entire metal stocks, which are listed as "copper on hand and in transit," are actually copper). For Miami, which does not publish any figures on gold or silver output or on the per-pound value of its metal stocks, determination of actual sales is impossible, although the report does give the average price received per pound of copper.

It will be noted that for certain companies no figures are given relating to stocks of metal. These companies sell their copper on a custom basis, and the value of such metals as they have on hand represents only copper in process or transit. Naturally, these companies are also the ones that receive prices corresponding most closely to *E.&M.J.* average quotations.

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Butte Copper & Zinc, producing manganese and lead-zinc ore from its mines in Montana, reports ore production of $18,756 in the first quarter of 1931. The net loss was $1,395, compared with $18,593 lost in the corresponding period of 1930.

Waite-Ackerman-Montgomery, operating a copper property in the Rouyn district of Quebec, reports an operating profit of $33,738 in 1930 but a net loss of $4,704 after depreciation and development charges. Net value of metal production was $116,916.

Financial Notes

Howe Sound, operating properties in Canada and Mexico, reports net income of $319,698 in the first quarter of 1931; $391,137 in the last quarter of 1930. The company produced metals valued at $2,704,720, compared with $3,177,235. Copper and gold output was lower; lead, zinc, and silver production was higher.

Amparo Mining, operating silver properties in Mexico, reports net loss of $74,029 in 1930, after depletion and tax payments. Operating loss was $16,214, compared with $48,543. Value of production was $459,480 and total assets, on Dec. 31, 1930, were $2,929,868. Of this, $727,467 was current assets and $14,112 current liabilities.

Hollinger Consolidated, operating a gold property in Canada, reports an operating profit, before depreciation or depletion, of $982,946 in the first quarter of 1930; production was valued at $2,613,342 from 405,451 short tons of ore. Comparable figures in the first quarter of 1929 were $1,084,379 operating profit, $2,588,407 production, and 401,431 tons.

Natomas Company, operating six gold dredges in California, reports an income of $533,142 in 1930. The dredges handled 14,901,143 cu.yd. of material, from which $1,369,415 was recovered, or 9.19c. a cubic yard. Net profit was 3.58c. a cubic yard. The company has reserves sufficient to maintain operations up to 1940.

Castle Peak Quicksilver has declared a dividend of 50c. a share, payable April 27. Its last dividend, also 50c. a share, was paid in September, 1930. Total dividends since starting operations in September, 1929, have been $2 a share. On April 14 of this year the company sold 100 flasks of quicksilver at $101 a flask in San Francisco. Production was resumed on March 8 after a short shutdown due to frozen pipe lines. The management has announced that production costs are about $50 a flask.

Copper Production, Sales, and Stocks

Company Index	1929 Production, Pounds Copper	1929 Sales Pounds Copper	1929 Price Cents Per Pound	Stock on Hand Dec., 31 1929, Pounds Copper	Stock Valued at Cents Per Pound	1930 Production, Pounds Copper	1930 Sales, Pounds Copper	1930 Price Cents Per Pound	Stock on Hand Dec. 31, 1930, Pounds Copper	Stock Valued at, Cents Per Pound
Calumet & Ariz	130,486,607	89,054,392	18.118	(e)	(e)	88,839,719	138,486,957	11.332	(e)	(e)
Calumet&Hecla	123,830,000	116,821,096(a)	17.690	(e)	(e)	105,740,000	71,208,760(a)	12.09	(e)	(e)
Cons. Copper mines	22,731,703	17,860,769(a)	(e)	9,791,803	12.50	32,612,203	33,286,150(b)	13.17	9,117,856(b)	10.50
Engels Copper	11,000,162	11,000,162	18.13	.....	.....	4,072,628	4,072,628(c)	15.146(c)	.....	.....
Granby	60,854,591	60,854,591	18.13	.....	.....	46,831,149	46,831,149	12.65	.....	.....
Howe Sound	43,032,641	43,032,641	18.12	.....	.....	45,266,927	45,266,927	12.65	.....	.....
Inspiration	107,516,201	(e)	(e)	43,579,860(a)	11.133	65,606,664	86,287,704(a)	11.32(a)	22,889,820(a)	9.667
Int. Nickel	87,823,945(a)	81,833,776	(e)	(e)	(e)	125,332,785(d)	109,743,747	(e)	(e)	(e)
Iron Cap	4,417,770	4,417,770	17.85	.....	.....	6,924,735	6,924,735	12.675	.....	.....
Isle Royale	10,864,085	8,320,909(a)	18.21	2,814,147(a)	14.01	10,659,413	9,277,811(a)	11.92	4,195,749(a)	12.97
Magma	38,239,310	38,442,084(a)	18.206	(e)	(e)	31,884,271	36,852,778(a)	12.238	(a)	(e)
Miami	58,841,159	(e)	18.10	(e)	(e)	67,124,596	(e)	14.87	(e)	(e)
Mohawk	20,043,127	13,526,450	18.363	10,507,916	7.316	2,706,762	7,151,328	14.692	6,063,350(f)	7.366
Nevada	266,274,918	(e)	16.752	116,379,369(a)	13.50	141,980,173	164,125,886(a)	12.207	94,233,656(a)	10.50
Old Dominion	18,943,441	(e)	17.932	9,661,384(g)	(e)	17,596,795	27,258,179	11.136	0(g)	0
Phelps Dodge	222,003,363	151,217,364	17.97	76,400,327(g)	.....	143,853,252	220,253,579	11.309	0(g)	0
Shattuck Denn.	12,736,160	12,736,160	18.176	4,222,721	12.50	10,048,220	7,517,121	15.95	6,753,820	10.00
United Verde Ex	64,111,941	56,783,299	(e)	20,737,846	(e)	45,567,228	56,613,038	(e)	9,692,036	(e)
Utah Copper	296,625,554	(e)	16.749	118,109,105(a)	13.50	161,138,717	190,737,373(a)	11.915	88,510,449(a)	10.50

(a) Not contained in company reports but obtained by correlation of other official figures.
(b) Copper sold in 1930 but not delivered that year included in sales and not included in stocks.
(c) Mine closed since July, 1930. (d) From source other than company report. (e) Not available. (f) Does not include stocks of concentrate with copper content of 10,600,000 lb. (g) Unsold copper only.

Tariff Board Investigation of Russian Asbestos

As the U. S. Tariff Commission's investigation into charges of unfair competitive methods in the importation of Russian asbestos promises to extend over a longer period than was first expected when the investigation was ordered March 30, the Treasury Department has been requested to issue an order permitting further entry of asbestos only under bond. This will permit the importation of asbestos for re-export either in its crude state or in the form of manufactured products, but its entry into consumption in this country is subject to risk of forfeiture of bond in the event that the Commission's findings sustain the charges preferred by the domestic producers. Ordinarily, the amount of the bond is fixed at double the value of the imported product.

No further importations of Russian asbestos are likely pending conclusion of the Commission's investigation, as stocks in this country are reported to be large. The Commission had no intention of ordering the exclusion of the Soviet product until N. E. Newman, president of Asbestos, Ltd., Inc., the selling agent for the Amtorg Trading Corporation, requested postponement of the hearing scheduled for May 19. Mr. Newman informed the Commission that a hearing on that date would interfere with his plans, made before the investigation was ordered, for a business trip to Europe. The Amtorg is reported as desiring prompt disposition of the case, but not could not prevail upon Mr. Newman to avoid postponement.

The date of the postponed hearing will be announced later. At the request of counsel for the Amtorg, the Commission also has extended from May 4 to a later date the time in which Asbestos, Ltd., and the Amtorg may file answer to the complaint filed by the Bear Canyon Asbestos Company, Amber, Pa., and Regal Asbestos Mines, Inc., New York, that the methods used in the sale of Russian asbestos in this country have induced buyers to break contracts for the purchase of the domestic product. In view of the delay in the proceeding Chairman Fletcher, of the Commission, announced that the order requiring bond was necessary to protect the interests of all concerned. It will be entered by the Treasury Department in accordance with the provisions of Section 337 (f) of the 1930 tariff act.

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Copper Range Net Lower

Net income, before deductions for depreciation or depletion, of Copper Range in 1930 was $104,841, compared with $839,742 in 1929. The company produced 23,799,770 lb. of copper, and operating revenue, at the average sales price of 11.4318c. a pound, was $2,720,735. Operating profit, before deduction of interest on the company's railroad's bonds, was $218,841. Current assets of Copper Range on Dec. 31, 1930, were $4,272,087, compared with assets of $5,374,098 at the end of 1929. Current liabilities, including a reserve for metal adjustments, were $758,750 at the end of 1930. After deduction of half Champion's net assets, the net excess of current assets over current liabilities was $3,079,583.

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Dome Mines Annual Report

Net profit, after income taxes, of Dome Mines in 1930 was $117,895, compared with $1,793,429 in 1929. Destruction of the company's mill, which resulted in a greatly decreased gold output, was responsible for the drop in earnings. Output, including recoveries from the mill wreckage, totaled $775,266 in 1930, or about one-fifth of the normal annual output. At the end of 1930, the surplus of the company was $2,283,973, compared with $3,172,172 at the beginning. Dividend payments were continued at the regular rate of $1 per share annually. At the end of 1930, total assets were $11,890,634, of which $5,591,746 was current assets and a "dividend assurance fund." Current liabilities were $478,499.

Production of Lead in Canada Reduced in February

Canada produced slightly more copper, zinc, nickel, and asbestos in February than in the preceding month, according to figures released by the Dominion Bureau of Statistics. Lead production declined sharply. Copper output in Canada during February amounted to 22,970,724 lb., of which total 5,570,000 lb. was from Quebec, 9,770,000 lb. from Ontario, 2,130,000 lb. from Manitoba, and 5,490,000 lb. from British Columbia.

Canadian lead production in February declined to the lowest point in two years. Output for the month totaled 19,326,869 lb., against 28,589,411 lb. in January of the current year, and 31,860,290 lb. in February, 1930.

Zinc produced in Manitoba and British Columbia in February totaled 20,553,489 lb., an increase of 1.8 per cent over the January output. The average price of zinc in Canada for the month of February was 2.67c. per pound, against 2.77c. in January.

Production of leading metals and minerals in Canada in the first two months of 1931 follows:

	January, 1931	February, 1931
Asbestos, tons	12,807	13,147
Copper, lb	21,859,908	22,970,724
Feldspar, tons	600	377
Gold, oz	202,785	195,118
Gypsum, tons	10,000	19,162
Lead, lb	28,589,411	19,326,869
Nickel, lb	6,500,944	6,693,185
Silver, oz	2,117,670	2,111,765
Zinc, lb	20,313,866	20,553,489

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Financial Notes

MAGMA COPPER reports net earnings of $111,425 in the first quarter of 1931, after depreciation, but before federal taxes, compared with $388,676 in the first quarter of 1930. Production in the 1931 quarter was 7,245,889 lb. of refined copper and the cost was 8.8c. a pound.

GOLD HILL DEVELOPMENT, operating a gold property in Nevada, reports a net profit of $2,677, after payment of interest charges and depreciation, in 1930. Production did not start until August. In the last five months of the year, $132,216 was produced from 14,575 short tons of ore milled. The company has a reserve of 12,330 short tons of broken ore on which all mining costs save transportation to mill have been paid.

DOME MINES, operating a gold mine in Ontario, reports a net profit of $448,148 in the first quarter of 1931, before depreciation or depletion. The new 1,500-ton mill, started late in 1930, produced $842,383 from 132,400 short tons during the quarter. Comparable results for 1930 are not available because the burning of the old mill in 1929 prevented production. In the third quarter of 1929, the last previous quarter in which production was continuous, net earnings were $464,764.

Mining Company Dividends for April, 1931

Companies in the United States	Situation	Per Share	Total Disbursements
Aluminum Company of America, pfd	Various	$1.50Q	$2,214,930
Castle Peak Quicksilver	Nevada	0.50	10,000
Cresson Consolidated, g	Colorado	0.01Q	12,000
Homestake Mining, g	S. Dakota	1.50MX	376,740
Kennecott Copper	Various	0.50Q	4,686,061
Magma Copper	Arizona	0.50Q	204,077
Newmont Mining, h	Various	1.00Q	452,760
Phelps Dodge, c	Various	0.50Q	1,411,270
Tom Reed, g	Arizona	0.03	60,000
U. S. Smelting, Refining & Mining	Various	0.25Q	121,587
U. S. Smelting, Refining & Mining, pfd	Various	0.875Q	425,557
Companies in Other Countries			
Dome Mines, g	Canada	0.25Q	238,333
Hollinger Consolidated Gold	Canada	0.05M	246,000
Howe Sound, c., l., s.	Mexico, Canada	0.75Q	372,029
N. Y. & Honduras Rosario	Honduras	0.50QX	100,000
Nipissing, s	Canada	0.075Q	90,000
Pioneer Gold Mines	Canada	0.03Q	50,000
Premier Gold, s., g	Canada	0.03Q	150,000
Wright Hargreaves, g	Canada	0.025Q	137,500
Total			$11,358,844

c, copper; s, silver; l, lead; z, zinc; g, gold; h, holding; Q, quarterly; M, monthly; X, extra.

Consolidated M. & S. Reports Large Drop in Revenue

After providing for current development, depreciation, depletion, and pension fund reserves, Consolidated Mining & Smelting reported a net profit of $2,755,317 in 1930, compared with $10,129,340 in 1929. The operating profit in 1930 was $7,136,072 on sales of $21,613,751. Production was 302,984,402 lb. of lead, 239,100,252 lb. of zinc, 14,127,185 lb. of copper, 456,582 lb. of cadmium, 6,936,759 oz. of silver, and 25,782 oz. of gold. All metals except silver and cadmium showed increases over the 1929 figures. Capital expenditure in 1930 was $9,280,011, of which $6,365,736 was spent for plant additions. The amount spent in construction of the new fertilizer plant was $3,280,859.

Total assets of the company on Dec. 31, 1930, were $56,576,299. Of this, $8,551,546 was in bonds, $280,199 in cash, $2,756,754 in accounts receivable, and $6,693,388 in ores, metals, and smelter products on hand. At the end of 1929, the last-named item was $5,507,174. The company's profit-and-loss account showed a balance of $9,352,603 at the end of the year. It was $13,493,459 at the beginning. In addition, the company has reserves of $18,545,998, including a contingent reserve of $5,000,000. Bank loan and overdrafts were $2,263,334 at the end of the year, which represents in large measure increased stocks of metal.

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Granby Report Shows Loss

In 1930, Granby Consolidated made a net loss of $482,624 on its operations, after deduction of all depreciation and depletion charges. In 1929, the same company showed a profit of $2,021,413. Gross value of Granby's production was $7,397,335, and on that a gross operating profit of $1,505,231 was realized. Production included 46,831,149 lb. of copper, 393,954 oz. of silver, and 8,435 oz. of gold. Copper cost per pound, before depletion or depreciation charges, was 9.796c. The company's total assets at the close of 1930 were $14,272,085, of which $5,348,180 represented current assets. Current liabilities were $487,035. At the close of the year, the company's surplus account showed a deficit of $1,711,869, compared with $1,229,245 at the close of 1929.

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Mother Lode Coalition

In 1930, Mother Lode Coalition reported a net income of $455,103, compared with $692,599 in 1929. This is after taxes, but before depletion. There is no depreciation charge. The company reported an operating profit of $518,197 on metal sales of $1,594,940. Production was 9,179 short tons of shipping ore, containing 9,646,800 lb. of copper and 75,004 oz. of silver. At the end of the year, capital-and-surplus account stood at $1,655,112, compared with $2,076,463 at the end of 1929. The shrinkage was due partly to the large depletion charge and partly to the adjustment of metals on hand. Current assets on Dec. 31, 1930, were $972,433. Liabilities included $61,156 in accounts payable and $77,107 in unpaid treatment, refining, and delivery charges.

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Magnesite Output in U. S. Declined During 1930

The total quantity of crude magnesite mined in the United States in 1930 was 129,320 short tons, with an approximate value of $1,033,130, according to reports furnished by producers to the U. S. Bureau of Mines. This represents a decrease of 31 per cent from the quantity mined in 1929 (187,660 short tons).

Sales of magnesite of domestic origin in 1930 were 8,580 short tons of caustic calcined, valued at $260,010, a decrease of 24.6 per cent in quantity and 35.8 per cent in value compared with 1929; and 49,460 short tons of dead-burned, valued at $903,450, a decrease of 37.1 per cent in quantity and 41.4 per cent in value compared with 1929. No crude magnesite was sold in 1929; in 1930, 1,120 short tons valued at $14,410 was reported sold.

Imports in 1930, according to the U. S. Bureau of Foreign and Domestic Commerce, were 856 short tons of crude magnesite, valued at $9,061; 3,403 short tons caustic calcined, valued at $78,107; and 46,936 short tons of dead-burned, valued at $702,456.

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Financial Notes

MAYFLOWER-OLD COLONY COPPER, development company operating in Michigan, reports a deficit of $11,302 on Jan. 1, 1931, compared with a balance of $3,991 at the beginning of the year. Failure of stockholders to pay assessments during the year forced the company to close down.

ANACONDA WIRE & CABLE, manufacturing subsidiary of Anaconda Copper, reports an operating profit of $2,345,056 in 1930, compared with $3,950,657 in 1929. After deducting administration and selling expenses, interest, taxes, and depreciation, net income was $278,992.

BUNKER HILL & SULLIVAN reports a profit for the first three months of 1931 of $408,367 after ordinary taxes, development costs, and other charges, but before depreciation and depletion. This compares with $672,787 in the same period last year.

Average Metal Prices for April, 1931

COPPER:	
Electrolytic, refinery	9.392
London Standard Spot	42.694
London Electrolytic, Bid	45.375
LEAD:	
New York	4.412
St. Louis	4.164
London Spot	12.375
London Forward	12.606
SILVER:	
New York	28.279
London	13.120
Sterling Exchange	485.764
ZINC:	
St. Louis	3.717
London Spot	11.353
London Forward	11.838
TIN:	
Straits	25.222
London Standard Spot	112.775
QUICKSILVER	102.077
ANTIMONY	6.888
PLATINUM, Refined	26.346
CADMIUM	55.000
ALUMINUM, 99 Per Cent Plus	23.300

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U. S. Copper Consumption by Industries

Domestic consumption of copper in 1930 amounted to 958,850 tons, against 1,159,800 tons in 1929, and 990,800 tons in 1928, according to preliminary figures released by the American Bureau of Metal Statistics.

Copper consumption in the United States, industrially classified, for the last three years, in short tons, follows:

	1928	1929	1930
Electrical manufacturers	213,000	261,000	224,000
Telephone and telegraph	119,000	164,000	122,000
Light and power lines	115,000	127,000	130,000
Other wire	87,100	106,200	93,700
Wire cloth	7,100	9,000	9,200
Automobiles	127,400	137,600	86,900
Buildings	62,000	59,000	50,000
Railway equipment	6,000	9,600	8,600
Shipbuilding	1,600	2,400	5,000
Castings, (a)	72,500	79,500	55,400
Ammunition	8,200	6,900	5,100
Copper bearing steel	1,600	2,600	1,900
Radio sets	8,400	15,500	13,000
Refrigerators	13,800	17,200	15,000
Radiators—heating	1,100	1,300	1,800
Other uses	80,300	86,100	66,750
Manufactures for export	66,700	74,900	70,500
Totals	990,800	1,159,800	958,850

(a) Not elsewhere specified. Includes bearings, bushings, valves, pipe fittings and similar material.

The estimate of copper in building is exclusive of the wiring and electrical equipment.

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Mining Corporation

Mining Corporation shareholders, at the meeting in Toronto, approved a change in the par value of the stock from $5 to no par. The number of shares has been increased to 2,000,000, of which 339,950 will remain in the treasury (and will probably be used in financing equipment of the new Ashley gold deposit, in Ontario).

Copper Sells at 9c., Equaling All-Time Low—Lead and Zinc Decline

New York, May 7, 1931.—With no improvement in the general business situation, the trend in prices in non-ferrous metals again was downward. Copper sold on the last three days at 9c., delivered Connecticut, equaling the all-time low set in 1894. Lead was lowered in price a full half cent during the last two weeks to stimulate buying. Prime Western zinc dropped to 3.25c., the lowest price in 35 years, and Straits tin sold down to 22.75c., the lowest level since 1902. Sales of copper and lead were fairly good at the revised prices, but zinc has been comparatively quiet on the decline to the 3.25c. basis, owing largely to the reluctance of sellers to offer the metal in quantity. Tin weakened in sympathy with the general decline in commodity prices. Quicksilver was fairly steady. Platinum made a new low for the movement. The *E. & M. J.* weighted index of non-ferrous metal prices for April was 64.45, a new low.

Copper Down ½c.

With demand for copper products disappointing, consumers could not be induced to take on additional tonnages except at concessions. The depressed state of the financial markets, coupled with the feeling that the business situation can hardly be expected to show much change until late in the third quarter, added to the weakness in copper. The price fell from 9½c. to 9c. in the last two weeks. The custom smelters, whose intake seems not to have been cut down to an appreciable extent by low prices, were unable to get more than 9c. on the last three days of the period. Offerings on the 9c. basis, however, were readily absorbed. During the week ended May 6, more than 8,000 tons of copper were sold, about half of which was at the 9c. level. The groups of large producers did not participate in the selling below 9½c.

The price of Copper Exporters, Inc., was reduced from 10.05c. to 9.80c., c.i.f. usual European ports, on April 29. On May 7 the export price was lowered to 9.775c., passing along the recent cut in freights. Export sales during April totaled 23,000 long tons, against 20,000 long tons in March, and 60,000 long tons in February.

The April statistics are expected to show an increase in stocks of refined copper. Serious consideration will be given to further curtailment of production, according to reports in copper circles. Messrs. Pisart and Gutt, officials of the Katanga group, arrived in New York on May 4.

Zinc Scarce at 3¼c.

The price of zinc has again declined, this time a total of 30 points in two weeks. As the price lowers, however, producers are less and less inclined to sell, and the last sales made by some important interests were at 3.35c. In the last two days a few hundred tons was sold as low as 3.25c., with some of the smaller producers the principal sellers, for both prompt and forward. London on Monday hit a new all-time low at £10-7/16 and the general opinion is that world production will be so seriously curtailed at present prices that any further declines of importance are unlikely. Domestic production in April, shown in the following tabulation, was at a new low, but as shipments dropped to 27,400 tons, stocks increased by about 1,700 tons. It is understood that all of this increase was in Prime Western, as producers of High-Grade have curtailed sufficiently to just about offset shipments.

Domestic zinc statistics, in tons, for March and April, according to the American Zinc Institute, follow:

	Mar.	Apr.
Production	32,328	29,137
Production, daily average	1,043	971
Shipments	35,224	27,418
Stock, end of month	141,493	143,212
Retorts operating end of month	34,221	29,072
Retorts operating, aver. for month	33,047	29,165
Unfilled orders	31,216	36,150

Note: There were no exports of zinc in either March or April.

Lead Buying Improves

Lead at 4c., New York, and 3.80c., St. Louis, attracted a good volume of business. The tonnage sold in the last week exceeded 3,500 tons, which was well above the average of recent weeks. A feature in the market was the tonnage sold for prompt and May shipment. Virtually all the large consumers were well represented in the week's sales total. One producer reported that he was able to dispose of his current intake without any difficulty and that an increase in demand at the current level of prices was not so welcome. Other operators were not disposed to force business, and the market appeared to be fairly steady in all directions.

Sales of lead for April shipment were estimated at slightly more than 34,000 tons. New business booked during April was about 7,000 tons short of the quantity shipped, leading to the assumption that consumers are still under-bought. The buying of prompt and near-by lead during the last week would tend to substantiate this view.

Foreign demand for lead was quiet until May 6, when an excellent tonnage was sold. Some details remain to be worked out in connection with the foreign lead restriction plan, but traders believe that receipts in Europe will show some effects of the agreement in another month.

The April lead statistics for the United States are not expected to reveal much of a change in the situation. Stocks in the hands of producers will probably show a moderate increase. Receipts of ore are coming down.

Tin Sells Below 23c.

Influenced largely by continued weakness in other metals, as well as the depressed state of the rubber market, tin prices in London declined to new low levels. In New York, Straits tin, prompt shipment, sold down to 22.75c., a new low for the movement and the lowest price recorded since 1902. A fair volume of business was placed on the decline. On the last two days of the period under review, prices steadied, though chiefly on covering by shorts in London. The April statistics showed a decrease of 145 long tons in the so-called world's visible supply of tin.

Silver Quiet

The silver market remained quiet and steady with only narrow fluctuations in price. The small daily supplies have been purchased for China account, as Indian rates are still quoted under New York parities.

Zinc and Lead Concentrates

On May 2, the Joplin, Mo., market for zinc concentrate, basis 60 per cent, settled at $20 per ton, against $22 on April 18. Lead concentrate, basis 80 per cent, was quoted at $35, against $45 two weeks ago.

Other Metals

ALUMINUM—Per lb., delivered, Alcoa commercial and mill ingot, 99 and 98 per cent, 23.30c.; Alcoa No. 12 alloy, 22c.; metallurgical ingot, 94 per cent plus, 23.30c.; 98@99 per cent, 22.90c. London, £85, less 2 per cent, per long ton, for 98 per cent ingots and bars.

ANTIMONY — Per lb., duty paid, Chinese spot, 6.70c.; futures, 6.60c. Cookson's "C" grade, spot 12c. "C.M.C." grade, 99.9 per cent, spot, 11c.

BISMUTH—Per lb., $1.50.

CADMIUM—Per lb., 55c.

IRIDIUM—Per oz., $115@$125 for 98 @99 per cent sponge and powder.

NICKEL — Per lb. electrolytic cathodes, 35c.; shot and ingot made from remelted electro, 36c., for single lots of spot metal. London, per long ton, £170 @£175, as to quantity.

PALLADIUM—Per oz., $19@$21.

PLATINUM—Per oz., official price of leading interest was reduced from $26 to $23 on April 30. Cash transactions between dealers several dollars less.

QUICKSILVER—Per 76-lb. flask, $101 @$102. Demand has been fair. London reports the market unchanged at £22 7s. 6d. per flask.

Chromium, Cobalt, Magnesium, Man-

Daily Prices of Metals

April May	Electrolytic Copper	Straits Tin	Lead		Zinc
	Refinery	New York	New York	St. Louis	St. Louis
23	9.275	24.85	4.35	4.15	3.525
24	9.275	24.65	4.25	4.05	3.525
25	9.275	24.55	4.25	4.05	3.50
27	9.275	23.85	4.25	3.85	3.475
28	9.275	23.75	4.10	3.85	3.40
29	9.225	23.75	4.00	3.80	3.40
Av'ge	9.267	24.233	4.200	3.958	3.471
30	9.15@9.275	23.25@23.375	4.00	3.80	3.35
1	9.025	23.50	4.00	3.80	3.35
2	8.90	23.25	4.00	3.80	3.325@3.35
4	8.775	22.75@23.00	4.00	3.80	3.35
5	8.775	23.25	4.00	3.80	3.25
6	8.775	23.45	4.00	3.80	3.25
Av'ge	8.910	23.273	4.000	3.800	3.315

Average prices for calendar week ended April 25, 1931, are: Copper, 9.275c.; Straits tin, 24.688c.; New York lead, 4.392c.; St. Louis lead, 4.167c.; zinc, 3.560c.; and silver, 28.646c.

Average prices for calendar week ended May 2, 1931, are: Copper, 9.152c.; Straits tin, 23.569c.; New York lead, 4.058c.; St. Louis lead, 3.817c.; zinc, 3.385c.; and silver 28.375c.

The above quotations are our appraisal of the major markets for domestic consumption based on sales reported by producers and agencies. They are reduced to the basis of cash, New York or St. Louis, as noted. All prices are in cents per pound.

Copper, lead, and zinc quotations are based on sales for both prompt and future deliveries; tin quotations are for prompt delivery only.

In the trade, copper prices are quoted on a delivered basis; that is, delivered at consumer's plant. As delivery and interest charges vary with the destination, the figures shown above are net prices of refineries on the Atlantic seaboard. Delivered prices in New England average 0.225c. per pound above those quoted.

Quotations for copper are for the ordinary forms of wirebars and ingot bars. For ingots an extra 0.05c. per pound is charged; for slabs, 0.075c.; and for cakes, 0.125c. up depending on weight. Cathodes are sold at a discount of 0.125c. per pound.

Quotations for zinc are for ordinary Prime Western brands. Zinc in New York is now quoted at 0.35c. per pound above St. Louis, this being the freight differential. The contract price for High-Grade zinc delivered in the East and Middle West is 1c. above the St. Louis price for Prime Western.

Quotations for lead reflect prices obtained for common lead, and do not include grades on which a premium is asked.

Silver, Gold, and Sterling Exchange

Apr.	Sterling Exchange "Checks"	Silver		Gold, London	Apr. May	Sterling Exchange "Checks"	Silver		Gold, London
		New York	London				New York	London	
23	4.85 15/16	28 7/8	13 5/16	84s 9 3/4d	30	4.86 1/4	28	13 3/16	84s 9 3/4d
24	4.86	28 1/2	13 1/4	84s 10 1/4d	1	4.86 1/8	28 1/4	13	84s 9 3/4d
25	4.85 13/16	28 1/2	13 1/4	.....	2	4.86 3/16	28 1/4	13 3/16	.....
26	4.85 15/16	28 3/4	13 3/8	84s 10 1/4d	4	4.86 3/16	28 3/8	13 1/8	84s 9 3/4d
28	4.86 3/16	28 1/2	13 1/4	84s 9 3/4d	5	4.86	28 1/4	13 3/16	84s 10 1/8d
29	4.86 1/8	28 1/2	13 1/4	84s 9 3/4d	6	4.86 1/8	28 3/8	13 3/16	84s 11 1/2d

Average for week ended April 29: Silver, 28.604c.; Sterling Exchange, $4.86000
Average for week ended May 6: Silver, 28.250c.; Sterling Exchange, $4.86146

New York quotations are as reported by Handy & Harman and are in cents per troy ounce of silver, 999 fine. London silver quotations are in pence per troy ounce of bar silver, basis of 925 fine. Sterling quotations represent the demand market in the forenoon. Cables command three-sixteenths of a cent premium.

London

Apr. May	Copper Standard		Electrolytic (Bid)	Tin		Lead		Zinc	
	Spot	3 M		Spot	3 M	Spot	3M	Spot	3 M
23	42 3/8	43 1/16	45 1/2	111 3/4	112 5/8	12 1/4	12 7/16	11 1/4	11 7/16
24	42 3/8	43 1/4	45 1/2	111	112 3/8	12 1/8	12 5/16	11	11 3/8
27	41 5/8	42 5/16	44 1/2	108 1/2	109 3/8	11 7/8	12 1/16	10 9/16	11
28	41 13/16	42 7/16	44 1/2	107 1/4	108 5/8	12 1/8	12 3/16	10 9/16	11
29	41 11/16	42 3/8	44 1/2	107 7/8	109 1/8	11 7/8	11 15/16	10 5/8	11 1/16
30	41 3/16	41 13/16	44	104 1/2	105 7/8	11 5/8	11 3/4	10 1/2	10 7/8
1	40 7/8	41 1/2	44 1/4	105 1/2	106 3/4	11 5/8	11 7/8	10 5/8	11 1/16
4	39 7/8	40 1/8	43 1/2	102 7/8	104 1/4	11 7/16	11 3/4	10 7/16	10 15/16
5	40	40 11/16	43	103 3/4	105 1/8	11 11/16	11 15/16	10 1/2	11
6	40 5/16	40 15/16	43	105 1/2	106 3/4	11 7/8	12 1/8	10 11/16	11 3/16

Prices for lead and zinc are the official price for the morning session of the London Metal Exchange; prices for copper and tin are the official closing buyers' prices. All are in pounds sterling per long ton (2,240 lb.).

ganese, Molybdenum, Osmium, Radium, Rhodium, Ruthenium, Selenium, Silicon, Tantalum, Tellurium, Thallium, and Tungsten are unchanged from prices given in the April 27 issue.

Metallic Ores

Prices in tons of 2,000 lb., or in "Units" of 20 lb., unless otherwise stated.

CHROME ORE — Per long ton, c.i.f. Atlantic ports, Russian and Indian ores, 46 to 48 per cent CR_2O_3, $19.

MANGANESE ORE—Per long ton unit of Mn, c.i.f. North Atlantic ports, cargo lots, exclusive of duty of 1c. per lb. of Mn contained; Indian, 48 to 50 per cent, 26@27c., nominal; South African, 52 to 54 per cent, 25@26c.; 50 to 52 per cent, 24@25c.; 44 to 46 per cent, 23½c. Caucasian, 52@55 per cent, 25@26c.

TUNGSTEN ORE — Per unit of WO_3, New York: Chinese wolframite, duty paid, $11.25. Bolivian scheelite, $11.50; domestic scheelite, $12.

Antimony, Beryllium, Iron, Molybdenum, Tantalum, Tin, Titanium, Vanadium, and Zircon ores are unchanged from prices given in April 27 issue.

Metallic Compounds

ARSENIOUS OXIDE (White arsenic)—Per lb., 4c., delivered, all positions.

COPPER SULPHATE (Blue Vitriol)—Per lb., in car lots, 4.25c.

For prices on Calcium Molybdate, Cobalt Oxide, Germanium Dioxide, Sodium Nitrate, Sodium Sulphate, Zinc Oxide, and Zirconium Dioxide see issue of April 27.

Rolled Metals

COPPER — Per lb., sheets, hot-rolled, 19⅜c.; wire, f.o.b. mill, 11¼c.

LEAD SHEETS — Per lb., full rolled, 7¼c.; clipped, 7½c.

MONEL METAL — Per lb., sheets, full finished, 42c.; rods, hot-rolled, 35c.

MUNTZ METAL—Per lb., rods, 15⅞c.; plates, 18¾c.

NICKEL—Per lb., sheets, full finished, 52c.; rods, hot-rolled, 45c.

NICKEL SILVER — Per lb., sheets, 10 per cent, 24⅛@24½c.; 18 per cent, 27⅝@28c. Wire and rods, 10 per cent, 27⅝c.; 15 per cent, 31⅝c.; 18 per cent, 35⅛c.

PHOSPHOR BRONZE — Per lb., sheets and rods, 5 per cent tin, 30⅝c.; wire, 5 per cent, 31⅛c.; 10 per cent, 36⅝c.

ZINC SHEETS — Per lb., 8¾c., f.o.b. works; ribbon, 8¼c.; 7 per cent discount on orders for 18 tons or more.

Iron, Steel, and Coke

IRON — Per gross ton, Valley furnaces: Bessemer, $17; basic and No. 2 foundry, $16.50.

STEEL—Per gross ton base prices. Pittsburgh, billets and slabs, $30; plates and structural shapes, per 100 lb., $1.65; soft steel bars, $1.65.

COKE—Per ton, Connellsville furnace, $2.40@$2.50. Connellsville foundry, $3.25@$4.85. Byproduct coke, Ohio and Kentucky (Connellsville basis), $5.50; Buffalo, $8@$8.50; Detroit, $8.50.

Metal Statistics

Monthly Average Prices of Metals

(See daily price table for basis of quoting)

Silver

	New York		London Spot		Sterling Exchange	
	1930	1931	1930	1931	1930	1931
January	45.000	29.423	20.896	13.810	486.447	485.260
February	43.193	26.773	20.008	12.432	485.784	485.551
March	41.654	29.192	19.298	13.524	485.933	485.596
April	42.428	28.279	19.554	13.120	486.019	485.764
May	40.736	.....	18.850	.....	485.724	.....
June	34.595	.....	16.049	.....	485.625	.....
July	34.346	.....	15.928	.....	486.300	.....
August	35.192	.....	16.283	.....	486 839	.....
September	36.315	.....	16.738	.....	485.888	.....
October	35.846	.....	16.563	.....	485.719	.....
November	35.908	.....	16.625	.....	485.454	.....
December	32 635	.....	15.201	.....	485.413	.....
Year	38 154	.....	17.666	.....	485.929	.....

New York quotations, cents per ounce troy, 999 fine. London, pence per ounce, sterling silver, 925 fine. Sterling exchange in cents.

Copper

	F.O.B. Refinery		London Spot			
	Electrolytic		Standard		Electrolytic	
	1930	1931	1930	1931	1930	1931
January	17.775	9.838	71.469	44.938	83.250	47.524
February	17.775	9.724	71.419	45.372	83.500	47.950
March	17.775	9.854	69.202	44.818	83.405	47.699
April	15.621	9.392	62.075	42.694	74.338	45.375
May	12.756	.....	53.159	.....	59.545	.....
June	12.049	.....	50.003	.....	56.750	.....
July	11.023	.....	48.277	.....	52.522	.....
August	10.693	.....	47.525	.....	50.725	.....
September	10 310	.....	46.264	.....	49.500	.....
October	9.597	.....	43.030	.....	45.772	.....
November	10.113	.....	46.134	.....	48.963	.....
December	10.300	.....	46.771	.....	50.065	.....
Year	12.982	.....	54.611	.....	61.528	.....

New York quotations, cents per pound. London, pounds sterling per long ton.

Lead

	New York		St. Louis		London			
	1930	1931	1930	1931	1930 Spot	1930 3 Mos.	1931 Spot	1931 3 Mos.
January	6.250	4.802	6.100	4.604	21.545	21.571	13.872	13.905
February	6.236	4.552	6 086	4.340	21.188	21.097	13.444	13.550
March	5.662	4.527	5.542	4.276	18.807	18.940	13.128	13.355
April	5.537	4.412	5.428	4.164	18.319	18.363	12.375	12.606
May	5.523	.....	5.408	.....	17.795	17.861	.....	.....
June	5.410	.....	5.310	.....	17.941	17.994	.....	.....
July	5.250	.....	5.149	.....	18.160	18.063	.....	.....
August	5.488	.....	5.340	.....	18.294	18.178	.....	.....
September	5.500	.....	5.348	.....	17.909	17.798	.....	.....
October	5.151	.....	4.999	.....	15.747	15 674	.....	.....
November	5.100	.....	4.950	.....	15.934	15.931	.....	.....
December	5.100	.....	4.950	.....	15.283	15.292	.....	.....
Year	5.517	.....	5.384	.....	18.077	18.064	.....	.....

New York and St. Louis quotations, cents per pound. London, pounds sterling per long ton.

Tin and Cadmium

	New York		London		Cadmium
	1930	1931	1930	1931	1931
	Straits		Spot		
January	38.851	26.137	175.466	115.798	67.115
February	38 676	26.315	173.750	117.919	55.000
March	36.798	27.065	164.851	121.852	55.000
April	36 077	25.222	162.638	112 775	55.000
May	32.108	.....	144.818	.....	.....
June	30.336	.....	136.300	.....	.....
July	29.822	.....	134.511	.....	.....
August	30.044	.....	134.988	.....	.....
September	29.647	.....	132.631	.....	.....
October	26.802	.....	117.451	.....	.....
November	25.904	.....	113.519	.....	.....
December	25.262	.....	111.560	.....	.....
Year	31.694	.....	141.873	.....	.....

New York quotations, cents per pound. London, pounds sterling per long ton.

Zinc

	St. Louis		London			
	1930	1931	1930 Spot	1930 3 Mos.	1931 Spot	1931 3 Mos.
January	5.229	4.035	19.634	20.241	12.747	13.113
February	5.180	4.012	19.209	19.778	12.303	12.694
March	4.934	4.002	18.304	18.810	12.190	12.676
April	4.843	3.717	17.819	18.378	11.353	11.838
May	4.641	.....	16.639	17.330	.....	.....
June	4.441	.....	16.422	17.038	.....	.....
July	4.350	.....	16.171	16.777	.....	.....
August	4.360	.....	15.953	16.469	.....	.....
September	4.270	.....	15.773	16.080	.....	.....
October	4.059	.....	14.446	14.935	.....	.....
November	4.266	.....	14.706	15.238	.....	.....
December	4.099	.....	13.762	14.214	.....	.....
Year	4.556	.....	16.570	17.107	.....	.....

St. Louis quotations, cents per pound. London pounds sterling per long ton

Antimony, Quicksilver, and Platinum

	Antimony (a) New York		Quicksilver (b) New York		Platinum (c) New York	
	1930	1931	1930	1931	1930	1931
January	8.606	7.317	121.192	103.000	61.923	36.000
February	8.830	7.069	120.500	100.205	59.909	34.000
March	8.236	7.127	118.808	100.423	54.769	29.538
April	7.740	6.888	114.000	102.077	46.462	26.346
May	7.454	.....	117.269	.....	46.000	.....
June	7.057	.....	118.600	.....	46.000	.....
July	6.976	.....	117.462	.....	43.692	.....
August	7.839	.....	116.000	.....	41.462	.....
September	7.773	.....	113.620	.....	36.080	.....
October	7.288	.....	110 596	.....	36 000	.....
November	7.105	.....	106.717	.....	36.000	.....
December	7.099	.....	105 346	.....	36.000	.....
Year	7.667	.....	115.009	.....	45.358	.....

(a) Antimony quotations in cents per pound, for ordinary brands. (b) Quicksilver in dollars per flask of 76 lb. (c) Platinum in dollars per ounce.

Pig Iron[1] and Aluminum

	Bessemer		Basic		No. 2 Foundry		Aluminum	
	1930	1931	1930	1931	1930	1931	1930	1931
Jan	19.00	17.50	18.50	17.00	18.50	17.00	24.300	23.300
Feb	19.00	17.29	18.50	16.79	18.50	16.79	24.300	23.300
March	19.00	17.00	18.50	16.50	18.50	16.50	24.300	23.300
April	19 00	.....	18.50	.....	18.50	.....	24.300	23.300
May	19.00	.....	18.50	.....	18.50	.....	24.300	.....
June	19 00	.....	18 50	.....	18.50	.....	24.140	.....
July	18.62	.....	18 12	.....	18.12	.....	23.300	.....
Aug	18.50	.....	18 00	.....	18 00	.....	23.300	.....
Sept	18.38	.....	17 76	.....	17 88	.....	23.300	.....
Oct	17.85	.....	17 00	.....	17.22	.....	23.300	.....
Nov	17.50	.....	17.00	.....	17.00	.....	23.300	.....
Dec	17 50	.....	17 00	.....	17.00	.....	23.300	.....
Year	18.53	.....	17 99	.....	18.02	.....	23.787	.....

Iron in dollars per long ton. Aluminum in cents per pound, 99 per cent grade.

[1]F.o.b. Mahoning and Shenango valley furnaces; freight to Pittsburgh, $1.76.

Monthly Crude Copper Output in Short Tons

Domestic

	1929 Total	1930 Total	1930 Dec.	1931 Jan.	1931 Feb.	1931 Mar.
Alaska shipments	21,947	18,953	1,817	837	627	563
Calumet & Arizona	65,246	45,161	3,166	3,236	3,237	3,189
Magma	19,118	15,940	1,203	1,197	1,202	1,223
Miami	29,567	34,568	2,611	2,348	1,745	2,025
Nevada Cons	133,140	70,990	(d) 16,583	.....	.....	.....
Old Dominion (a)	11,172	10,428	879	577	576	580
Phelps Dodge (b)	111,026	72,308	5,151	5,155	5,184	5,188
United Verde Extens	29,669	21,908	1,236	1,412	1,610	1,618
Tennessee Corp	7,870	7,772	646	659	585	611

Foreign

Andes Copper	60,538	47,428	3,499	3,503	.....	.....
Braden	88,155	79,923	8,588	8,595	.....	.....
Boleo, Mexico	12,898	13,940	(d) 3,288	.....	.....	(d) 3,250
Chile	150,247	89,100	7,121	7,120	.....	.....
Furukawa, Japan	17,767	.....	1,595	1,489	1,542	.....
Howe Sound	21,516	22,633	(d) 5,231	.....	.....	.....
Messina	(c) 7,200	.....	896	857	749	843
Mt. Lyell	9,731	10,878	(d) 2,504	.....	.....	(d) 2,699
Sumitomo, Japan	20.180	15,429	1,367	1,324	1,129	1,433

(a) Includes Arizona Commercial. (b) Moctezuma is included. (c) Estimated. (d) Three months.

Monthly Production of Primary Copper from U. S. Mines and Daily Rate (Short Tons)

	1929		1930		1931	
	Monthly Production	Daily Rate	Monthly Production	Daily Rate	Monthly Production	Daily Rate
January	86,324	2,785	67,838	2,188	48,059	1,550
February	84,735	3,026	59,196	2,114	47,504	1,697
March	93,698	3,023	61,216	1,975	48,543	1,566
April	94,902	3,163	60,450	2,015	.....	.....
May	93,392	3,013	60,238	1,943	.....	.....
June	82,354	2,745	56,743	1,891	.....	.....
July	79,229	2,556	54,249	1,750	.....	.....
August	78,885	2,545	56,779	1,832	.....	.....
September	79,402	2,647	56,584	1,886	.....	.....
October	82,575	2,664	55,954	1,805	.....	.....
November	75,934	2,531	53,141	1,771	.....	.....
December	74,772	2,412	48,518	1,565	.....	.....
Total	1,006,203	.....	690,263	.....	114,106	.....
Monthly average	83,850	.....	57,522	.....	48,035	.....
Av. of daily rate	.....	2,757	.....	1,891	.....	1,601

Mining Share Prices—Month of April, 1931

Company Name	High	Low	Last	§Most Recent Dividend		
NEW YORK STOCK EXCHANGE						
Ahumada Lead	0.50	0.37½	0.37½	April, 1927		0.12½
Alaska Juneau	15½	11½	13½	Ap. 10, My. 1, 1931	Q	0.10
American Metal	19¼	14¼	16	December, 1930	Q	0.25
Am. Metal, pfd			89*	Fe. 17, Mh. 2, 1931	Q	1.50
Am. Sm. & Ref	48	37½	37½	Ap. 17, My. 31, 1931	Q	1.00
Am. Sm. & Ref. 2nd, pfd.	101½	97½	97½	My. 8, Je. 1, 1931	Q	1.50
Am. Sm. & Ref., pfd	138½	132	132	My. 8, Je. 1, 1931	Q	1.75
Am. Zinc, L. & S	6.00	4.50	5.00	May, 1917		1.00
Am. Zinc, L. & S., pfd.	36½	30	30	October, 1930	Q	1.50½
Anaconda	35	26¾	27½	Ap. 11, My. 18, 1931	Q	0.37½
Andes Copper	15½	12½	12½	Ja. 10, Fe. 9, 1931	Q	0.25
Butte C. & Z	1.12½	0.87½	0.87½	December, 1929		0.50
Butte & Superior	1.87½	1.50	1.50	December, 1929	Q	0.50
Callahan Zinc-Lead	0.87½	0.62½	0.62½	December, 1920		0.50
Cal. & Arizona	39¾	33	33	June, 1930		0.50
Cal. & Hecla	9.00	7.50	7.50	June, 1930		0.50
Cerro de Pasco	24	15½	17½	Ap. 16, My. 1, 1931	Q	0.50
Dome Mines	12¾	10½	11	Mh. 31, Ap. 20, 1931	Q	0.25
Federal M. & S	61	57	57	June, 1927		10.00
Federal M. & S., pfd			94*	Fe. 26, Mh. 16, 1931	Q	1.75
Freeport Texas	39	27½	29	My. 15, Je. 1, 1931	Q	0.75
Granby Con	18½	13½	14	Ja. 16, Fe. 2, 1931	Q	0.50
Greene Cananea			74½*	July, 1930		0.75
Homestake	98	90	94	Ap. 20, Ap. 25, 1931	M	0.50
Howe Sound	24½	18⅝	19½	Mh. 31, Ap. 15, 1931	Q	0.75
Inspiration	9.00	6.25	7.12½	July, 1930		0.50
International Nickel	18⅝	14⅛	14⅛	Mh. 2, Mh. 31, 1931	Q	0.15
Int. Nickel, pfd	121½	119½	119½	Ja. 3, Fe. 2, 1931	Q	1.75
Kennecott	25⅛	20⅛	21⅛	Mh. 12, Ap. 1, 1931	Q	0.50
McIntyre-Porcupine	26⅛	22⅛	24	My. 1, Je. 1, 1931	Q	0.25
Magma Copper	21	15½	16½	Mh. 31, Ap. 15, 1931	Q	0.50
Miami Copper	8.62½	7.00	7.00	August, 1930		0.375
Mother Lode	0.62½	0.50	0.50	June, 1930		0.10
National Lead	121⅛	112½	113	Mh. 13, Mh. 31, 1931	Q	1.25
National Lead, pfd. A	141	140	140	My. 29, Je. 15, 1931	Q	1.75
National Lead, pfd. B	119	118	118	Ap. 17, My. 1, 1931	Q	1.50
Nevada Con	11⅛	8.50	8.75	Mh. 13, Mh. 31, 1931	Q	0.25
Park Utah Con	1.75	1.37½	1.50	July, 1929	Q	0.20
Patiño M. & E	11½	8.50	8.75	December, 1929		4s.
Phelps Dodge	21½	18	18⅛	De. 13, Ja. 2, 1931	Q	0.50
Rand Mines	34½	34⅛	34½	August, 1930		1.52
St. Joseph Lead	22⅛	15⅛	16⅛	Je. 9, Je. 20, 1931	Q	0.25
Seneca Copper	1.25	1.00	1.00			
Tennessee Corp	7.62½	6.00	6.50	Fe. 28, Mh. 16, 1931	Q	0.125
Texas Gulf Sulphur	50	36⅞	38⅛	Mh. 2 Mh. 16, 1931	Q	1.00
U. S. S. R. & M	21	15⅛	16⅛	Ap. 2, Ap. 15, 1931	Q	0.25
U. S. S. R. & M., pfd	47	45	45	Ap. 2, Ap. 15, 1931	Q	0.875
Utah Copper	120	115	120	Mh. 13, Mh. 31, 1931	Q	2.00
Vanadium Corp	66⅛	37⅛	41	Fe. 2, Fe. 16, 1931	Q	0.75
NEW YORK CURB EXCHANGE						
Aluminum Co. of Am	189	143	149			
Alum. Co. of Am., pfd.	109½	107½	108⅞	Mr. 14, Ap. 1, 1931	Q	1.50
Anglo-Chilean Con	15	9.00	9.37½			
Bunker H. & S	50	45	45	Mh. 26, Ap. 16, 1931	M	0.25
Carnegie Metals	1.50	1.50	1.50			
Con. Coppermines	3.25	2.25	2.50			
Copper Range	6.75	6.75	6.75	July, 1930		0.25
Cresson Con	0.56½	0.37½	0.43¾	Mh. 31, Ap. 10, 1931	Q	0.01
Cusi Mexicana	0.75	0.50	0.62½			
Evans-Wallower	1.87½	1.12½	1.12½			
Federated Metals	10⅛	8.50	8.75	Ja. 5, Ja. 15, 1931	Q	0.25
Hecla Mining	6.62½	4.50	5.25	Fe. 15, Mh. 15, 1931	Q	0.10
Hollinger Con	8.75	8.00	8.00	My. 6, My. 20, 1931	M	0.05
Hudson Bay M. & S	5.87½	4.50	4.75			
Iron Cap Copper	1.00	0.87½	1.00			
Mayflower Associates	47	38¼	38¼	Mh. 2, Mh. 16, 1931	Q	0.50
Mining Corporation	2.62½	2.00	2.00	December, 1929		0.12½
New Jersey Zinc	46⅜	35	41⅛	Ap. 20, My. 9, 1931	Q	0.50
Newmont Mining	46½	37½	39⅜	Mh. 31, Ap. 15, 1931	Q	1.00
N. Y. and Honduras	12	10⅛	10⅛	Ap. 14, Ap. 25, 1931	QX	0.50
Nipissing	1.62½	1.00	1.25	Mh. 31, Ap. 20, 1931	Q	0.075
Noranda Mines	27⅛	22	22½	October, 1930		0.50
Ohio Copper	0.50	0.25	0.25	September, 1926		0.03
Premier Gold	1.12½	0.62½	0.75	Mh. 13, Ap. 4, 1931	Q	0.03
Quincy	5.00	5.00	5.00	March, 1920		1.00
Shattuck Denn	5.00	3.50	4.00			
So. Am. Gold & Plat	1.25	1.12½	1.12½			
Teck-Hughes	9.00	7.75	8.00	Ja. 17, Fe. 1, 1931	Q	0.15
Tonopah Mining	0.75	0.50	0.50	Octobor, 1929		0.07½
United Eastern			0.06½*			
United Verde Ex	13⅜	8.12½	8.87½	Ap. 2, My. 1, 1931	Q	0.50
Utah-Apex	1.12½	1.00	1.00	December, 1929		0.025
Yukon Gold	0.43¾	0.12½	0.43¾	June, 1918		0.02
BOSTON STOCK EXCHANGE						
Ariz. Commercial	1.00	0.50	1.00	Fe. 21, Fe. 28, 1931	IL	1.00
East Butte	0.25	0.20	0.25	Fe. 16, Mh. 4, 1931	L	2.00
Isle Royale	5.50	3.50	3.50	March, 1930		0.50
Mohawk Mining	20⅛	17	18½	Ja. 31, Fe. 28, 1931	Q	0.25
Old Dominion	3.50	3.00	3.00	December, 1918		1.00
Utah Met. & Tunnel	0.50	0.35	0.35	December, 1927		0.30
MONTREAL						
Asbestos Corp	0.50	0.40	0.40	January, 1926		1.50
Asbestos Corp., pfd	1.50	1.00	1.00	January, 1930		1.75
Consolidated M. & S	161	105	113	De. 30, Ja. 15, 1931	SAX	6.25

Company Name	High	Low	Last	§Most Recent Dividend		
SPOKANE						
Constitution	0.07¾	0.05	0.05			
Dayrock	1.10	0.55	0.55	March, 1930		0.03
Golconda	0.39	0.21	0.21	July, 1929		0.02
Jack Waite Con	0.41	0.22	0.22			
Los Lugos	0.02½	0.01½	0.01¾			
Mexican Premier	0.13½	0.10	0.10	January, 1930		0.01
Montana Mines	0.24½	0.15	0.15½			
Noble Five	0.05	0.03	0.03	January, 1930		0.005
Pend Orielle	1.35	0.90	0.90			
Sherman Lead	0.40½	0.25	0.25	March, 1930		0.01
Sidney	0.09½	0.05	0.05	October, 1929		0.01
Sunshine Mining	1.55	1.21	1.28	December 20, 1930	Q	0.03
Tamarack & Custer	0.22½	0.15	0.15	September, 1924		0.25
SALT LAKE CITY						
Chief Con	0.64	0.55	0.55	February, 1928		0.10
Combined Metals	0.09¼	0.08½	0.08½			
Eureka Bullion	0.17	0.11½	0.12			
Eureka Lilly	0.17	0.12	0.12			
Moscow Silver	0.36	0.30	0.30			
New Quincy	0.06	0.01	0.05½	September, 1929	Q	0.10
North Lily	0.98	0.75	0.78	January, 1930		0.15
Park Bingham	1.25	0.75	0.75			
Park City Con	0.23	0.17½	0.17½			
Rico Argentine	0.04½	0.04	0.04¼	December, 1929		0.03
Silver King Coalition	5.00	3.70	3.75	De. 20, Ja. 2, 1931	Q	0.15
Tintic Lead	1.35	1.20	1.20			
Tintic Standard	4.05	3.40	3.40	March 31, 1931	Q	0.10
Walker Mining	1.72½	1.40	1.40	April, 1930		0.075
TORONTO						
Abana Mines	0.18	0.13½	0.14			
Amulet Mines	0.39	0.30	0.31			
Base Metals	0.17½	0.12	0.13			
Barry-Hollinger	1.25	1.00	1.00			
Canam Metals	0.04	0.02½	0.03			
Castle-Trethewey	0.21	0.18	0.21			
Central Manitoba	0.17½	0.12	0.13			
Falconbridge	1.68	1.25	1.35			
Howey Mines	0.30	0.24	0.25			
Keeley	0.26	0.25	0.26	March, 1928		0.04
Kirkland Lake	0.93	0.63	0.68			
Lake Shore	28½	26½	27	Mh. 2, Mh. 16, 1931	Q	0.30
Sherritt Gordon	1.15	0.85	0.86			
Siscoe Gold	0.55	0.44	0.53			
Sylvanite	1.14	0.84	0.84	De. 5, De. 20, 1930	SA	0.02
Treadwell-Yukon	2.15	2.00	2.00			
Ventures	0.72	0.50	0.51			
Vipond Con	1.22	1.05	1.05	April, 1927		0.03
Waite-A.-M	1.70	1.25	1.30			
Wright-Hargreaves	3.02	2.80	2.88	Mh. 14, Ap. 1, 1931		0.025
ST. LOUIS, CINCINNATI, AND DENVER						
Consolidated L. & Z	2.25	2.25	2.25	December, 1929		0.125
Eagle-Picher	6.00	4.12½	4.50	April, 1930		0.20
Eagle-Picher, pfd	80	80	80	De. 31, Ja. 15, 1931	Q	1.50
Empire Chief	0.02	0.01½	0.02			
Star of Utah	0.50	0.40	0.49			
Tungsten Prod	0.12½	0.09	0.12½			
West Gold	0.03	0.00¾	0.01			
SAN FRANCISCO, LOS ANGELES, AND COLORADO SPRINGS						
California Copper	0.75	0.37½	0.50			
(a)Golden Cycle	14½	14	14	Fe. 28, Mh. 10, 1931	Q	0.40
(a)Granite Gold	0.20	0.19	0.19	Mh. 27, Ap. 1, 1931	Q	0.01
Idaho-Maryland	0.53	0.41½	0.46			
Tom Reed	1.36	1.10	1.13	Mh. 16, Ap. 1, 1931		0.03
(a)United Gold	0.08¾	0.08½	0.08¾	February, 1930		0.01

‡LONDON

Company Name	High	Low	Last	Most Recent Dividend (Per Cent, Unless Noted)
Anglo American	18/9	15/–	16/3	22½, Feb. 19. 1930
Aramayo Mines	27/–	23/9	23/9	5, Oct. 23, 1929
Burma Corporation	9/4½	8/3	8/7½	1½, Dec. 10, 1930(b)
Camp Bird	7½d	4½d	6d	16¼, April 25, 1928
Fresnillo			8/3*	25 cents, Feb. 12, 1930
Frontino & Bolivia	11/6	9/3	10/7½	3¾, January, 1929
Lake View & Star	11/–	9/3	10/4½	11¼, 1921
Mexican Corporation	4/9	4/6	4/6	10, Oct 24, 1929
Oroville Dredging	2/3	2/–	2/–	37½, May 16, 1930
Rhokana Corporation	160/–	122/6	125/–	
Rhodes.-Select. Trust	20/1½	15/7½	16/3	
Rio Tinto	560/–	472/6	472/6	10s, April, 1931
St. John del Rey	21/3	20/1½	21/–	3¾, Nov. 21, 1930
San Francisco Mines	13/7½	12/–	12/9	10, Jan. 7, 1931
Santa Gertrudis	7/9	7/–	7/1½	7½, Jan. 8, 1931
Selukwe	2/9	2/1½	2/6	6¼, April 2, 1917
So. American Copper	2/9	2/–	2/1½	
Tanganyika	32/6	25/3	25/7½	2½, Aug 2, 1930
Wiluna Gold	18/10½	17/3	17/9	
Union Minière	6,450	5,880†	(c)	240 francs, July, 1931

Salt Lake Stock Exchange courtesy J. A. Hogle & Company, Spokane Standard Exchange courtesy the Pohlman Investment Company. *Not traded in. †Belgian Francs. ‡The above London quotations are for the month ended April 17. Q, quarterly; I, initial; M, monthly; X, extra; SA, semi-annual; L, liquidating. §Total dividends paid during the month will be found tabulated in the Market and Financial News Section. Dates here given are those of closing of books and payment of dividend. (a) Bid prices. (b) 1¼% (2 annas) dividend, and bonus of ¼% (1 anna). (c) This quotation is not available.